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W. C. EBAUGH

Permanent Secretary Denison Scientific Association

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BLACK RIVER AND OTHER CEPHALOPODS FROM
MINNESOTA, WISCONSIN, MICHIGAN, AND
ONTARIO

(PART II)¹

AUG. F. FOERSTE

Received October 18, 1932; published April 7, 1933

RASMUSSENOCERAS Gen. nov.

Genotype.—*Lambeoceras* (?) *leveannulatum* Troedsson. On the Middle and Upper Ordovician Faunas of Northern Greenland; Jubilaeumsekspeditionen nord om Grønland, 1920-23, 50, pl. 25, figs. 1-3 (1926).

Differing from typical *Lambeoceras* chiefly in the structure of its siphuncle, the segments of this siphuncle being distinctly taller than wide, and expanding but little within the camerae. The sutures of the septa curve downward strongly dorsally and ventrally, but do not curve outward on approaching the lateral angles of the conch. The cross-section of the conch is lenticular, but the lateral angles are a little more rounded. The location of the siphuncle is near the ventral side of the conch, as in the genus named. The only species definitely referable to this genus is the genotype.

Triptero-ceras xiphias (Billings) has a similar siphuncle, but its dorsal side is distinctly more convex than its ventral one and its lateral angles are more narrowly rounded. The type of *Triptero-ceras scofieldi* Foerste exposes only one of the flattened faces of the conch. This is only moderately convex in a transverse direction, and probably is the ventral side of the conch. Its cross-section probably is similar to that of *Triptero-ceras xiphias*. Both of these species are retained in *Triptero-ceras*.

The cross-section of *Allumettoceras subequilaterale* Miller resembles that of *Rasmussenoceras*, rather than that of *Allumettoceras*,

¹ Part I, including Table of Contents and all Plates, cf. Jour. Sci. Labs. Denison Univ. 27, 47-136 (1932).

the ventral part of its cross-section not being strongly flattened. Its siphuncle, however, is larger and apparently agrees more nearly with that of the species described here as *Lambeoceras confertus* Foerste than with the type of *Lambeoceras*.

SACTOCERAS Hyatt

Genotype.—*Orthoceras richteri* Barrande, Système Silurien du Centre de la Bohême, vol. 2, text 3, p. 570, pls. 318, 322, 323, 349 (1874).

Conchs resembling *Orthoceras* in general appearance, but with almost globular segments of the siphuncle, truncated at top and bottom, where these segments meet at the septal necks. These necks are short, and their interior surface is lined with annular deposits of calcareous material, which in vertical sections appear more or less lunate. While evidently similar in structure to the early stages of development of the calcareous deposits within actinoceroids, it is not known at present that the final form of these deposits, with central endosiphon and lateral *tubules*, is reached.

In addition to forms strictly conforming to the structure of the genotype, it is customary to refer to *Sactoceras* also those species with relatively small siphuncles in which the segments of the siphuncle are approximately globular, but in which no annular calcareous deposits are detected enveloping the inner surface of the septal necks.

58. *Sactoceras josephianum* Sp. nov.

Plate 9, figs. 2 A, B; 3 A, B

Specimen 112 mm. long, slightly curved lengthwise, its maximum curvature being along the lower half of its length. Its dorsoventral diameter enlarges from 5.1 mm. at its lower end to 15.1 mm. at a point 75 mm. farther up, and to 21.2 mm. after an additional interval of 35 mm., its apical angle being 8 degrees along its lower two-thirds, apparently increasing farther up. The cross-section of the conch is circular. Where the diameter of the conch is 18 mm., 6 camerae occupy a corresponding length. The concavity of the septa here is 2.5 mm. The location of the center of

the siphuncle is slightly ventrad of the center of the conch. Its segments are nearly globular in form, expanding from between 2.2 mm. and 2.75 mm. at the septal necks to 4 mm. at mid-height within the camerae. The shell is about one-fourth of a millimeter thick and its surface is ornamented by numerous coarse granules or low papillae which, in general, are irregularly arranged, but which along the smaller end of the specimen tend to be arranged in vertical rows, and which along one of the dorso-lateral sides of the conch are at several points arranged more or less radially, so as to resemble the astrophorae of the stromatoporoidea. No. 14472. Plate 9, fig. 2 A.

A second specimen (14473), 55 mm. long, has about 7 camerae in a length equal to its diameter. Where its diameter is 17.5 mm. the siphuncle narrows to 2.2 mm. at the septal necks, and its segments expand to 4 mm. at mid-length of the camerae. Since the camerae are only 2.7 mm. in length, the segments of the siphuncle appear distinctly, though moderately, flattened vertically. The septal necks are 0.3 mm. long, and the lower face of each connecting ring is adnate to the inner part of the underlying septum for a width of 0.5 mm. No. 14473. Plate 9, fig. 2 B.

A third specimen (14474), 135 mm. long, also is distinctly, though only slightly, curved lengthwise. At 90 mm. above its base its dorsoventral diameter is 29 mm. Its angle of enlargement immediately below is 8 degrees. At this rate of enlargement the diameter of the specimen at the uppermost part preserved was at least 35 mm. Since all of this specimen belongs to the phragmacone, the original length of the latter probably was about 230 mm., to which must be added an unknown length belonging to the living chamber.

A fourth specimen (14475), 100 mm. long, is of interest chiefly because it shows the lengthwise curvature of the more apical part of the conch, and retains the granulose ornamentation of the surface of the shell in an excellent state of preservation. The radius of curvature of its convex ventral side is about 180 mm., that of its concave dorsal side being nearer 150 mm. The upper part of the specimen is nearly straight. Its diameter enlarges from 2.6 mm. at its base to 14 mm. at its top. Plate 9, fig. 3 A.

Occurrence.—St. Joseph Island, in the northwestern part of Lake Huron; in the Black River. In the museum of the University of Michigan. This is the species cited by Rominger in his Palaeozoic Rocks of Michigan (Geol. Surv. Michigan, 1, pt. 3, 65, 66 (1873)), under the name *Orthoceras granulosum*, from the strata exposed on Encampment d'Ours and St. Joseph Islands, in the northwestern part of Lake Huron, Ontario.

A fifth specimen (14476), 36 mm. long and 12 mm. in diameter at midlength, has the center of the siphuncle about 5 mm. from the ventral wall of the conch. Notwithstanding this moderate excentricity, the segments of the siphuncle are strongly oblique and on its ventral side the septa are almost straight in vertical sections, both rising at an angle of 25 degrees above the horizontal, the greatest concavity of the septa being 4 mm. from their dorsal outline, and therefore located dorsad of the siphuncle itself. Hence the sutures of the septa rise almost the height of one camera ventrally. Plate 9, fig. 3 B.

Remarks.—The specimens here described as *Sactoceras josephi-anum* are similar to *Orthoceras tyronense* Foerste, described from High Bridge, Kentucky, where they occur in the Tyrone member of the Lowville division of the Black River (Jour. Sci. Labs. Denison Univ. 17, 139 (1912)). This similarity extends to the rate of enlargement of the conch, the globular form of the segments of the siphuncle, and the presence of an encrusting papillose species of *Dermatostroma*. How constant this species of *Dermatostroma* is in selecting for support the same species of *Sactoceras* is unknown. The St. Joseph specimen attains a much larger size than any found at High Bridge, and it is more distinctly curved lengthwise at its smaller end.

59. *Sactoceras pictolineatum* Sp. nov.

Plate 9, figs. 5 A, B, C

Specimen 35 mm. long, enlarging at an angle of 7 degrees, and attaining a maximum diameter of 14.7 mm. at its top. Its minimum diameter here is 13 mm. Five and a third camerae occur in a length equal to the maximum diameter. The concavity of the uppermost septum is estimated at 2 mm. The location of the

siphuncle is about half a millimeter from the center, along the longer axis of the conch at its top. Ten millimeters from the lower end of the specimen, where its shorter diameter is estimated at 11 mm., the septal neck is 1 mm. in diameter and the segment of the siphuncle widens to 2.6 mm. at mid-height within the camera, its general form being approximately globular. The surface of the shell is thin and that part which is assumed to be ventral is ornamented by numerous vertical color bands, darker than the intermediate parts of the shell. This color-banded part occupies three-tenths of the circumference of the conch. Within this area there are 30 dark lines, occurring at the rate of 6 in a width of 2 mm. along the greater part of the width of the area, but diminishing to 4 in 2 mm. along the right margin of the color-banded area, and a corresponding widening of the intervals between the color bands appears to take place also on the left side of this area. The coloring occupies a very thin portion of the shell immediately below its surface. The overlying part of the shell appears to loosen readily from the colored part, so that the latter frequently weathers into a series of vertical, and very shallow, grooves. The individual color-bands are between one-sixth and one-fifth of a millimeter in width, and usually are slightly narrower than the intermediate spaces. In addition, the surface of the shell is minutely striated transversely, these transverse lines scarcely being visible even under a lens.

Occurrence.—Found in the drift at Ann Arbor, Michigan, and lithologically resembling the Black River limestone along the northeastern shore of St. Joseph Island, in the northwestern part of Lake Huron. For this reason it is referred provisionally to the Black River. Holotype, No. 13357, in the museum of the University of Michigan. This is the specimen mentioned by Rominger on page 66 of his report on the Palaeozoic Rocks of Michigan, published in vol. 1 of the Geol. Surv. of Michigan in 1873.

Remarks.—This species belongs to a large and wide-spread group of species typified by the species described by Hall as *Orthoceras strigatum* from the Trenton at Middleville, New York. This group is characterized by the narrowness and unusually large number of the vertical color bands within the color-banded area.

60. *Sactoceras tyronense* Foerste*Plate 10, fig. 5*

Orthoceras tyronense Foerste, Jour. Sci. Labs. Denison Univ. 17, 139, pl. 10, figs. 5 A, B. (1912).

Holotype 37 mm. long, enlarging within this length from a diameter of 6 mm. at its base to 11 mm. at its top; very slightly curved lengthwise. Where its dorsoventral diameter is 10 mm. the center of the siphuncle is 4 mm. from the convex ventral wall of the conch. At its top there is a trace of the interior of a segment of the siphuncle, almost 3 mm. in diameter, and subglobular in form, but truncated at top and bottom, suggesting relationship to *Sactoceras*. At the top of the specimen there is a slight exposure of the surface of the shell, and this is smooth. The surface of the shell is completely encrusted by a thin layer of *Dermatostroma tyronense* Foerste, from one-fifth to one-fourth of a millimeter in thickness. The surface of this *Dermatostroma* in the specimen here described is papillate, the papillae numbering about 7 in a length of 5 mm. They tend to be arranged in vertical lines, forming more or less continuous ridges. In accompanying specimens the papillae are coarser and more strongly ridged.

Occurrence.—High Bridge, Kentucky; in the Tyrone member of the Black River formation. No. 87109, in the U. S. National Museum.

61. *Sactoceras* (?) *ottawaense* (Billings)*Plate 9, fig. 4*

Orthoceras ottawaense Billings, Geol. Surv. Canada, Rep. Progress for 1853–56, 331 (1857).

The following is the original description:

Section circular, tapering at the rate of about one line to the inch, from a diameter of seven lines; siphuncle small, nearly central, slightly dilated; septa at the diameter of seven lines, six in thirteen lines, about ten to the inch at a diameter of four lines; they are rather convex and a little oblique, their dorsal margin most approximate to the aperture. The siphon appears to be more eccentric towards the apex than it is near the aperture. At a diameter of two lines and a half, its center is one line and a half from the center of the fossil, but at the diameter of seven lines it is very nearly central.

This species somewhat resembles *O. recticameratum* (Hall), but differs in its regularly convex and distant septa. In the figure of that species, Pal. N. Y., vol. 1, plate 11, Figure 1d, at a distance of seven lines there are nine septa to the inch, and they are described by Professor Hall, as not curved, but passing obliquely in a line from the inside of the shell to the siphuncle, or *vice versa*. In one specimen at the same diameter there are scarcely six chambers to the inch, and the septa have a well rounded convexity of more than one line in height.

The specimen from which the above description has been drawn was collected at La Petite Chaudiere Rapids, on the River Ottawa, where it occurs associated with numerous species of fossils of the Black River and Trenton limestones; but in the vicinity of Union Bridge, two miles farther down the river, numerous fragments occur in the central part of the Trenton, which have the same proportions, and appear to me to be the same species. In this latter locality they are replaced and often filled by crystalline dolomite weathering of a light red color. The specimens are usually from four to five inches in length, rarely more than six inches, and almost always consist of the smaller extremity of the fossil.

Remarks.—The holotype of this species has been lost, so that nothing can be determined regarding its characteristics beyond what is known from the original description. According to the latter, the rate of enlargement of the conch was about 5 degrees. The statement that the siphuncle was small, nearly central, and slightly dilated is not sufficiently exact for diagnostic purposes, though sufficient to suggest its orthoceroid relationship. In the description of *Orthoceras ottawaense*, Billings stated that in the figure of the holotype of *Orthoceras recticameratum* Hall there are 9 septa to the inch where the diameter of the conch is 14 lines. A reference to the figure cited shows that this is the diameter at the top of the specimen, and that it is 9 camerae, rather than 9 septa, which occur in a length of one inch. The number 9 septa is correct only if the first of the series is not counted. Applying the latter procedure to Billings's description of *Orthoceras ottawaense*, it is inferred that 3.3 camerae occurred in a length equal to the diameter where the latter, at the top of the series counted, equalled 7 lines or 14.8 mm., and that about the same number, 3.3 camerae, occurred also in a length of 4 lines where the diameter of the conch was 4 lines or 8.5 mm. The sutures of the siphuncle evidently sloped slightly downward in a ventrad direction, the ventral side being that nearest the siphuncle. At a diameter of 14.8 mm. the location of the siphuncle was almost central.

Two specimens occur at present in the collections at Ottawa

under the name *Orthoceras ottawaense*. The one numbered 1719 probably came from the Union Bridge locality mentioned by Billings. It is imbedded in a dark gray granular limestone. Its surface is stained reddish brown, apparently by some oxide of iron. Its interior is occupied by coarsely crystalline dolomite which shows no structure except near the top of the specimen, where a single camera is outlined by the dark gray matrix filling its interior. The specimen is 94 mm. long. It enlarges from a diameter of 8 mm. at its base to 17 mm. at a point 72 mm. farther up, the angle of enlargement being 6.75 degrees. Where the diameter of the conch is 18.5 mm. the camera mentioned above is 4 mm. in height and the enclosing septa have a concavity of 4 mm. No trace of the siphuncle remains. It is not certain that this specimen belongs to the same species as the type.

The second specimen in the collections at Ottawa is 93 mm. long. Its lateral diameter enlarges from 17 mm. at its base to a diameter estimated at 25 mm. at a point 50 mm. farther up, the angle of enlargement apparently being 9.3 degrees. The number of camerae in a length equal to the lateral diameter of the conch equals 7. Where the lateral diameter of the conch is estimated at 25 mm., the concavity of the septa equals at least 5 mm. The location of the siphuncle is excentric. Where the diameter of the conch is estimated at 16 mm., the center of the siphuncle is 6 mm. from the ventral wall of the conch. Where this diameter is estimated at 23.5 mm., the center of the siphuncle is about 7.5 mm. distant. At this point the passage of the siphuncle through the septum is about 2.75 mm. in diameter. The form of the segments of the siphuncle is unknown, but it may have been similar to that of *Orthoceras hallanum* Miller, from the Richmond group of Ohio. Provisionally it is referred to *Sactoceras*. Plate 9, fig. 4, National Museum of Canada. No. 1719B.

62. *Sactoceras* (?) *ehlersi* Sp. nov.

Plate 12, fig. 11

Specimen 27 mm. long, enlarging in this length from a maximum diameter of 10.5 mm. at its base to 14.5 mm. at its top. Sutures of septa directly transverse. The number of camerae in a length

equal to the diameter of the conch increases from 7, where this diameter is 12 mm., to 9 at its top. At this top the concavity of the septa is 2.5 mm., the center of the siphuncle is 6.2 mm. from the nearer end of the longer diameter, and its segments contract from a diameter of 1.6 mm. at mid-height within the camerae to 1.1 at the septal necks, the height of the segment being 2 mm. The interior of the siphuncle is lined with a deposit of darker calcite, leaving a central space occupied by lighter colored calcite, locally white in color. The surface of the conch appears to have been smooth.

Occurrence.—St. Joseph Island, Lake Huron, Canada; in the Black River formation. No. 14479, Museum of Univ. of Michigan.

Remarks.—Specimen collected by Rominger, and by him labelled *Orthoceras ellipticum*. From this it is assumed that the cross-section was slightly elliptical, though in its present sectioned condition this can not be determined with accuracy.

ORMOCERAS Stokes

Genotype.—*Ormoceras bayfieldi* Stokes, Trans. Geol. Soc. London, 2nd ser., 5, 709, pl. 60, fig. 1, (1840); Foerste, Contrib. Mus. Geol. Univ. Michigan, 2, 62, text fig. 1; pl. 3, figs. 1 A, B, (1924).

Orthoconic actinoceroids with barrel-shaped segments of the siphuncle, central or nearly central in location, the siphuncle distinctly smaller in diameter than in *Armenoceras*, its segments not broadly nummuloidal. The contractions of the siphuncle at the septal necks are not as deep or narrow as in typical *Armenoceras*. In typical species the septa are adnate to the lower faces of the overlying connecting rings for an appreciable width, but are free from contact with the underlying connecting rings, the interval equalling at least the length of the septal necks.

63. *Ormoceras allumettense* (Billings)

Plate 17, figs. 1 A, B, C, D

Orthoceras allumettense Billings, Geol. Surv. Canada, Rep. Progress for 1853-56, 331 (1857); Barrande, Système Silurien du Centre de la Bohême, vol. 2, pt. 3, 729; pl. 437, figs. 6-9 (1874). Specimen 77 mm. long, enlarging laterally from a diameter of

19.5 mm. at its base to 29 mm. at a point 70 mm. farther up, the angle of enlargement being 8 degrees. Cross-section either circular or slightly depressed dorsoventrally. Six camerae occur in a length equal to the diameter of the conch. The sutures of the septa slope slightly downward in a ventrad direction. Where the diameter of the conch is 28 mm. the concavity of the septa equals 6 mm.; the center of the siphuncle is located 11 mm. from the ventral wall of the conch, and its segments are 9 mm. in diameter, so that the dorsal outline of these segments extends in a dorsad direction 2 mm. beyond the center of the conch. Where these segments are 9 mm. in diameter they narrow to 5 mm. at the septal necks, the length of the latter being only half a millimeter or a little less. Since the length of the camerae at this point is only 4.5 mm., the segments of the siphuncle are about twice as wide as tall, and hence appear strongly nummuloidal, though occupying only one-third of the width of the conch. The segments slope downward in a dorsad direction at an angle of about 10 degrees with the horizontal. The lower half of the siphuncle is slightly curved, its ventral outline being convex. Plate 17, fig. 1A.

Occurrence.—Paquette Rapids, at the lower end of Allumette Island, in the Ottawa River, province of Quebec, Canada; in the Leray member of the Black River formation. Lectotype; no. 1265, in the National Museum of Canada.

A second specimen, numbered 1265a (Plate 17, fig. 1B), is labelled as collected at Paquette Rapids by T. C. Weston, in 1872. Two other specimens, numbered 1265b, and 1265c (Plate 17, fig. 1D), were originally labelled as coming from lot 4, concession 3, Fitzroy township, in Carleton county, Ontario.

Remarks.—All four of the specimens listed under 1265 in the preceding lines expose the siphuncle by the weathering away of the ventral side of the conch, in distinct contrast with typical *Actinoceras*, in which it usually is the dorsal side which weathers away. Moreover, in all four specimens the ventral outline of the siphuncle is slightly curved in a convex direction.

The specimen figured by Barrande is a typical specimen of this species. Judging from the figures its cross-section was slightly depressed dorsoventrally, and its septal necks were very short.

64. *Ormoceras paquettense* Sp. nov.*Plate 17, fig. 5*

Associated with typical specimens of *Ormoceras allumettense* are fragments of a closely similar species which appears to differ chiefly in the strong downward slope of the sutures of its septa in a ventrad direction. It is possible that these fragments represent the more apicad parts of *Ormoceras allumettense*, but in specimens known to belong to the latter species the sutures are more nearly horizontal.

Occurrence.—Paquette Rapids, Ottawa River, Canada. No. 6839, National Museum of Canada.

65. *Ormoceras josephianum* Sp. nov.*Plate 17, figs. 2A, B*

Specimen 33 mm. long, enlarging at an angle of 7 degrees and attaining a diameter of 22 mm. at its top. Cross-section circular. The number of camerae in a length equal to the diameter of the conch is slightly more than 5. The sutures of the septa appear to be directly transverse or nearly so. The concavity of the septa is about 4 mm. The location of the siphuncle is central. Where the diameter of the conch is 21 mm., this siphuncle expands from a diameter of 3 mm. at the septal necks to 7 mm. at mid-height within the camerae, the height of these camerae being 4 mm., and the length of the septal necks being slightly over half a millimeter. The lower face of the connecting rings is in contact with the upper surface of the underlying septa for a width of slightly over 1 mm. around the septal necks. There are traces of actinoceroid structure, though the calcareous deposits within the siphuncle have altered to crystalline calcite.

Occurrence.—St. Joseph Island, in the northwestern part of Lake Huron; in the Black River. No. 14414 in the museum of the University of Michigan.

Remarks.—This species is characterized by its relatively large siphuncle, centrally located. Compared with *Ormoceras allumettense*, the segments of the siphuncle are relatively narrower, the

septal necks are shorter, and in consequence the general form of the intervening segments does not appear as strongly depressed vertically.

66. *Ormoceras hitzi* (Foerste)

Plate 14, fig. 1

Orthoceras (*Ormoceras* ?) *hitzi* Foerste, Jour. Sci. Labs. Denison Univ., 16, 77, pl. 1, fig. 3, pl. 2, fig. 22 (1910).

Specimen 70 mm. long, enlarging from a diameter of 10 mm. at its base to 15.5 mm. at a point 40 mm. farther up, its angle of enlargement being 8 degrees. The number of camerae in a length equal to the diameter of the conch increases from 4.5 at a diameter of 11 mm. to 6 at a diameter of 15 mm. The concavity of the septa at the top of the specimen equals 2.5 mm. Where the diameter of the conch is 11 mm., that of the siphuncle is 4.3 mm., narrowing to 2 mm. at the septal necks. The necks are 0.4 mm. in length, the septa being adnate to the base of the overlying segments of the siphuncle for a width of 1.6 mm. The interior of the siphuncle is filled with calcareous deposits of an actinoceroid structure. A central irregularly tubular space, the endosiphon, 0.6 mm. in diameter, is filled with whitish calcite, and from this the so-called *tubuli* branch off at mid-height of each camera, curving upward toward the outer margin of the segments of the siphuncle. As is so frequently the case with actinoceroids, the outer walls of these segments are not preserved. The location of the siphuncle appears to be nearly central. The surface of the unweathered shell is smooth, but where weathered it is vertically ribbed. The ribbed area apparently occupied about one-third of the circumference of the conch, and ribs are about 1 mm. apart along the middle of this area, where the diameter of the conch is 12 mm., but are located closer together on approaching the lateral margins of the ribbed area.

Occurrence.—Madison, Indiana; in the Hitz layer at the top of the Saluda division of the Whitewater member of the Richmond. The specimen here described and figured is the lectotype among the original 4 cotypes. No. 87114, U. S. National Museum.

Remarks.—This ribbed type of structure of the shell, seen only on weathered specimens, and confined to only about one-third of the circumference of the conch, is known from rocks as old as the Murfreesboro member of the Stones River division of the Chazy, in Tennessee, and is known thence as far up stratigraphically as the Shelby member of the Lockport division of the Niagaran. The species studied so far all belong to the groups at present included in *Sactoceras* and *Ormoceras*. Frequently this type of structure is associated with vertical color marking, the color bands resisting weathering less readily, and appearing as grooves on the weathered surface of the conchs.

67. *Ormoceras husseyi* Sp. nov.

Plate 37, figs. 1A, B

Specimen 170 mm. long, weathered so as to show the septa with a glimpse of the siphuncle on its interior, apparently enlarging from a diameter of about 30 mm. to 50 mm. in a length of 120 mm. The number of camerae increases from 4 in a length of 30 mm. along the lower end of the specimen to 5.5 camerae in a length of 50 mm. at its upper end. The sutures of the septa apparently are directly transverse. At the base of the specimen the siphuncle is 2 mm. from the ventral wall of the conch. Its segments are 7 mm. in length and 10 mm. in maximum diameter at mid-height within the camerae, contracting to 2.2 mm. or 2.4 mm. at the septal necks. These necks are about one-seventh or one-eighth of a millimeter in length. On the ventral side of the siphuncle the inner parts of the septal necks are directed almost horizontally inward; on its dorsal side these inner parts curve more distinctly downward. The basal part of the segments of the siphuncle is in contact with the septum beneath along an annular contact ring varying in width from 2 mm. ventrally to 2.5 mm. dorsally. The lunate calcareous deposits enveloping the inner margins of the septal necks, when examined in vertical sections of the siphuncle, apparently meet at the center of the necks, leaving no passage for the endosiphuncle, deposits enveloping successive septal necks being separated from each other by vertical intervals of 3 to 4 mm. They evidently are

typically actinoceroid in structure. The surface of the shell is smooth.

Occurrence.—Ford River, northern Michigan, at Hussey's locality 19; in the Trenton formation. No. 14465; Univ. of Michigan.

68. *Ormoceras* (?) *casei* Sp. nov.

Plate 17, figs. 4A, B

Specimen 79 mm. long, apparently enlarging laterally at an angle of 7 degrees. At a break 50 mm. below its top its lateral diameter is 21.5 mm. and its dorsoventral one is 18.5 mm. From this point it enlarges to a lateral diameter of 26.5 mm. and a dorsoventral one of 23.5 mm. at a level 33 mm. farther up. The cross-section of the conch is approximately elliptical with its longer axis in a lateral direction, but the ventral side of this section is slightly flattened. Where the lateral diameter of the conch is 22 mm., 5 camerae occupy a corresponding length. The suture of the septum here inclines slightly downward in a ventrad direction. The concavity of this septum is about 1.5 mm. The center of the siphuncle is located 2.1 mm. from the ventral wall of the conch. The passage of the siphuncle through the septum is 2.1 mm. in diameter. Several fragments of the siphuncle are exposed at the base of the specimen. Of these the second lowest segment is 2.7 mm. long, 3.1 mm. wide, narrowing to 2 mm. at the septal neck above, and apparently to 1.5 mm. at the neck beneath. The siphuncle here is 0.5 mm. from the ventral wall of the conch, this being the approximate distance also for the fifth and sixth segment above the base of the specimen. In general these segments appear of globular form, but truncated at top and bottom. At the break 50 mm. below the top of the specimen the shell is 1 mm. thick. At its top it is transversely wrinkled, 5.5 wrinkles occupying a length equal to the lateral diameter of the conch. In addition there are distinctly weaker wrinkles along the lower half of the specimen. The wrinkles slope downward in a ventrad direction at an angle of 12 degrees with the horizontal. Parallel to these wrinkles there are transverse striae or bands, somewhat like

those characteristic of *Geisonoceras*, about 8 in a length of 5 mm. In addition to the transverse bands there are faint transverse striae, visible only under a lens, and usually poorly preserved.

Occurrence.—St. Joseph Island, in the northwestern part of Lake Huron; in the Black River. No. 14463, in the museum of the University of Michigan.

69. *Ormoceras* (?) *menelaus* (Billings)

Plate 17, fig. 3

Orthoceras Menelaus Billings, Geol. Surv. Canada, Pal. Foss., 1, 26 (1865).

The original description follows:

Shell of medium size, tapering at the rate of $1\frac{1}{4}$ lines to the inch; section transversely broad-oval or nearly circular; septa from 10 to 12 to the inch where the diameter is from 10 to 15 lines; siphuncle cylindrical, excentric, between 2 and 3 lines in diameter where the shell is from 10 to 15 lines, its centre distant from the margin about once and a half its thickness. Surface unknown. The transverse section appears to be broad-oval in all the specimens that I have seen but I am not certain but that this feature is due to pressure. The siphuncle is a cylindrical tube a little dilated where the septa are attached to it and in most of the chambers (in the specimens observed) slightly constricted between the septa. This species is allied to *O. Murrayi* but differs therefrom in being more nearly circular in the transverse section; in having more numerous septa and the siphuncle more distant from the margin. It seems to be rare.

Locality and Formation.—Wolfe Island near Kingston; Pointe Claire on the Island of Montreal, and the fifth and sixth lots in the ninth concession of the Township of Tyendenaga. Black River limestone.

Remarks.—The types from Wolfe Island and Pointe Claire are lost, and the specimen from Tyendenaga does not preserve the structure of the segments of the siphuncle satisfactorily.

The original description presumably was based on the specimen from Wolfe island. Judging from this description about 7 camerae occurred in a length equal to the larger diameter of the conch where the latter was 20 mm. Farther up, where this diameter was 30 mm., about 13 camerae occurred in a corresponding length. The location of the center of the siphuncle was three-tenths of the diameter of the conch from the ventral wall of the latter, the diameter of the siphuncle being one-fifth of that of the conch. The most diagnostic feature appears to be presented by the si-

phuncle, which is described as cylindrical, but slightly constricted between the septa. This structure may prove of generic importance, distinguishing *Orthoceras menelaus* from typical *Orthoceras*. It certainly does not occur in the Tyendenaga specimen, which is the only one of the specimens mentioned by Billings which remains in the collections at Ottawa.

Tyendenaga specimen.—Specimen 130 mm. long, at present sectioned dorsoventrally in a vertical direction. Lateral diameter estimated to have increased from 22.5 mm. at its lower end to 34 mm. at a point 110 mm. farther up. In its present condition, the specimen is strongly depressed dorsoventrally, its dorsoventral diameter being 25 mm. where its lateral diameter is about 32 mm. However, this compression apparently is due, at least in part, to crushing after the death of the animal. Distinct traces of septa are preserved only in the lower 35 mm. of the length of the specimen. These slope downward at an angle of 5 degrees with the horizontal, in a direction toward the crushed side of the conch, assumed to be ventral. The number of camerae in a length equal to the lateral diameter of the conch equals about 11. At the lower end of the specimen the center of the siphuncle is from 9 to 10 mm. from that side of the conch assumed to be dorsal. Here the septal necks are about 1.7 mm. in diameter, one-fifth or one-sixth of a millimeter long, and with their lower margin or brim curving strongly outward. This outward curvature of the brim suggests a structure similar to *Ormoceras*, with segments enlarging distinctly within the camerae, but there are only poor traces of several of the connecting rings.

Occurrence.—Tyendenaga township, Hastings county; Ontario, Canada; in the Black River formation; in lots 5 and 6 of concession 9; in the Black River formation. No. 1288, National Museum of Canada.

Remarks.—This Tyendenaga specimen may not be congeneric with the original types from Wolfe island and Pointe Claire; at least, the segments of its siphuncle are not dilated where the septa are attached to it, nor slightly constricted between the septa.

However, constriction between the septa is a feature characteristic of the segments of the siphuncle of *Murrayoceras*.

ARMENOCERAS Foerste

Genotype.—*Actinoceras hearsti* Parks.—Trans. Royal Canadian Inst., 11, 73, pl. 6, fig. 5 (1915); *Armenoceras hearsti* Foerste, Contrib. Mus. Geol., Univ. Michigan, 2, 32, pl. 13, fig. 4 (1924); Journ. Sci. Labs. Denison Univ., 22, 68, pl. 8, fig. 4; pl. 24, fig. 5 (1927).

In the genotype the siphuncle is relatively large, strongly nummuloidal, and located close to the ventral wall of the conch. The segments of the siphuncle are strongly contracted at the septal necks, and these necks are very short, equalling about 0.7 or 0.8 mm. on their dorsal side and 0.6 or 0.7 mm. ventrally. The brim or lower part of the neck is strongly and abruptly curved outward, its width varying in different necks from slightly less than 1 mm. to 1.5 mm. On the dorsal side of the siphuncle the brim appears to be from 0.2 to 0.3 mm. distant from the overlying part of the septum, diminishing to slightly over 0.1 mm. at its nearest approach to the septa on the ventral side of these necks. The septa are adnate to the lower face of the overlying segments of the siphuncle for annular widths of 8 to 12 mm.

70. Armenoceras milleri (Foerste)

Plate 14, fig. 3

Orthoceras (Loxoceras) milleri Foerste, Jour. Sci. Labs. Denison Univ., 16, pl. 1, fig. 5; pl. 2, figs. 24A, B (1910).

Type specimen, length 87 mm., enlarging laterally from a diameter of 32 mm. below mid-length to 38 mm. at its top, 55 mm. farther up, the angle of enlargement being 3.5 degrees. The number of camerae in a length equal to the lateral diameter increases from 11 at diameter of 32 mm. to 12 at a diameter of 38 mm. The sutures of the septa slope only slightly downward in a ventrad direction on the lateral sides of the conch, but ventrally this slope increases to 5 degrees. The center of the siphuncle is 12 mm. from the ventral wall of the conch where its lateral diameter is 38 mm. and where its dorsoventral diameter is estimated at 37 mm. Where the lateral diameter of the conch is estimated at 29 mm. the diameter of the nummuloidal segments of the siphuncle is 9

mm., contracting to approximately 4 mm. at the septal necks. These necks are very short, and apparently about a fifth of a millimeter in length. The shell is thin and smooth.

Occurrence.—Two miles south of the Crow distillery, one mile southeast of McFee ferry, 7 miles south of Frankfort, Kentucky; in the Perryville member of the Trenton formation. No. 87113, U. S. National Museum.

71. *Armenoceras ehlersi* Sp. nov.

Plate 14, figs. 4A, B

Specimen 112 mm. long, enlarging laterally from a diameter of 27.5 mm. at its base to 29 mm. at the base of the living chamber, which is 73 mm. farther up. The conch is depressed dorsoventrally, its dorsoventral diameter being estimated at 25 mm. where its lateral diameter is 28 mm. The number of camerae in a length equal to the lateral diameter varies from 14.5 mm. along the lower part of the specimen to 16 mm. along its upper part. At the third septum beneath the base of the living chamber the concavity of this septum is 5 mm., but this concavity may be abnormal since it is not shown by the associated specimens evidently belonging to the same species. The siphuncle is in contact with the ventral wall of the conch at the base of the specimen, where its diameter is about 7 mm. No. 2040. Plate 14, fig. 4A.

A second specimen, 15 mm. long and at least 27 mm. in diameter, has 9 camerae in a length of 15 mm., corresponding to 16 camerae in a length equal to the diameter of the conch. The concavity of its septa is 3 mm. The siphuncle is 7 mm. in diameter, narrowing to 4.5 mm. at the septal necks. Since the individual segments of the siphuncle are only about 2 mm. in height, these segments appear broad and nummuloidal. The septal necks are about one-sixth of a millimeter in length, the connecting rings being free from contact with the lower face of the overlying septum but adnate to the upper face of the underlying one. There is no calcareous deposit on the inner wall of the septal necks nor on the interior of the connecting rings, as in typical *Actinoceras*. The shell of the conch is one-third of a millimeter thick. Its surface appears to have been relatively smooth. No. 14456. Plate 14, fig. 4B.

A third specimen is 27 mm. long, 27 mm. wide at its top, and has 16 camerae in a corresponding length. The siphuncle is exposed along its lower half and this has the same nummuloidal appearance as in the preceding specimen. No. 14457.

In a fourth specimen 44 mm. long and 25 mm. in diameter at its top there are 5 camerae in a length of 9 mm. near its top, while at its lower end 5 camerae occupy a length of 12 mm., thus suggesting that the lower part of the conch may have had distinctly longer camerae than its upper part. However, the lowest segment of the siphuncle has the same structure as in the preceding two specimens, being low and broadly nummuloidal, and clearly in contact with the ventral wall of the conch. No. 14458.

Occurrence.—St. Joseph Island, in the northwestern part of Lake Huron; in the Black River. A series of specimens numbered 2040, 14456, 14457, 14458, in the museum of the University of Michigan.

ACTINOCERAS Bronn

Genotype.—*Actinoceras bigsbyi* Bronn, *Lethaea Geognostica*, 1, 97–98, pl. 1, fig. 8 (1837); Foerste, *Contrib. Mus. Geol., Univ. Michigan*, 2, 31, pl. 1, figs. 1 A, B; 2 (1924).

Typical *Actinoceras* is characterized by its relatively large siphuncle located near or in contact with the ventral wall of the conch. The segments of this siphuncle are broadly nummuloidal, except at gerontic stages of growth, where, in certain species, these segments become much narrower, and in certain forms may even be elongated vertically. The septal necks are relatively long. The ventral side of the conch usually is more broadly rounded than its dorsal side, and may even be distinctly flattened. The sutures of the septa usually curve distinctly downward ventrally. The apical end of the conch has never been found. Not unfrequently the lower ends of the specimens terminate bluntly at a convex surface representing the lower side of one of the lower septa. Here the siphuncle is always filled with an actinoceroid calcareous deposit leaving a central columnar space which evidently is the endosiphuncle. The basal part of the ventral out-

line of the conch usually is convex, the overlying parts being straight.

Kochoceras Troedsson differs from typical *Actinoceras* chiefly in the strong flattening of its ventral side, resulting in a more conspicuous dorsoventral compression of its cross-section.

72. *Actinoceras turinense* Sp. nov.

Plate 18, figs. 1A, B

Cf. *Orthoceras* Bigsby, Trans. Geol. Soc. London, 1, 198, pl. 25, fig. 2 (1824).

Specimen 115 mm. long, consisting chiefly of the ventral half of the conch, exposing the siphuncle. It retains parts of 11 camerae, the one at the top and the one at the bottom not extending across the entire width of the conch. The conch enlarges laterally from a diameter of 42 mm. to 59 mm. in a length of 78 mm., its angle of enlargement in that direction being 12.5 degrees. The ventral part of its cross-section has a radius of curvature of about 50 mm. for a width of 40 mm., changing to a radius of 15 mm. ventrolaterally. The number of camerae in a length equal to the lateral diameter of the conch increases from 6 where this diameter is 51 mm. to 7 camerae where the diameter is 59 mm. At the top of the specimen the sutures of the septa curve downward 7 mm. ventrally below their level ventrolaterally. They curve downward also dorsad of this ventrolateral vertical area. The concavity of the septum at the top of the specimen is 6 mm. beneath the ventral outline of its suture. Along its septal necks the siphuncle is separated from the ventral wall of the conch by a distance of about 1.5 mm., at least along the upper part of the specimen. However, the crests of the connecting rings evidently are in flattened contact with this wall for variable distances, decreasing from about 20 mm. along the lower part of the specimen to about 3 mm. at the uppermost well-preserved camera, 60 mm. farther up. At the lowest camera preserved, the lateral diameter of the connecting ring of the siphuncle is about 26 mm., diminishing gradually toward its top, where this diameter is only 16.5 mm. The corresponding dorsoventral diameters of these rings are 25.5 mm. and 16.5 mm., the uppermost connecting ring being approxi-

mately circular in cross-section. Where the length of the camerae is 8 mm., the length of the septal necks is apparently about 1.75 mm., the remainder of the included segments of the siphuncle being formed by the connecting rings. The septal necks in this specimen therefore are considerably shorter than the connecting rings. The inner walls of the siphuncle evidently were lined with calcareous deposits which did not exceed 3 mm. in thickness in the lowest camera preserved, and which thinned thence upward. In the central part of the siphuncle there must have been originally an animal tissue capable of secreting the calcareous deposits mentioned above. After the death of the animal and the decay of this tissue there remained an open space, later filled with matrix, hardening into stone. At present, the calcareous deposits originally lining the interior of the siphuncle have disappeared, but the hardened matrix later occupying its central part remains. This central deposit of matrix is widest at the third and fourth camera above the lowest well preserved camera, and diminishes thence in diameter both toward the lower part of the specimen and toward its top. At approximately regular intervals it is rather sharply annulated, the annulations continuing as tubules toward mid-height of the adjacent connecting rings. Between these annulations this central deposit of matrix is broadly and rather deeply grooved in a transverse manner, the broadest diameter of this deposit of matrix within the grooves in the camerae mentioned above equalling about 19 mm. In the specimen at hand the lateral extension of the sharp crest of the annulations tends to be lamellar, rather than tubular.

Occurrence.—About half or three-quarters of a mile east of Turin railroad station, about 25 miles southeast of Marquette, Michigan; in a quarry located in the southwest quarter of the northwest quarter of section 30, township 44 north, range 23 west, in Marquette county, Michigan. Collected by K. I. Sawyer and donated by A. L. Sawyer. From the Beloit member of the Black River. Holotype, no. 13366, in the museum of the University of Michigan.

Remarks.—If the original of Bigsby's figure 1 on his plate 25, cited above, be regarded as the type of *Actinoceras bigsbyi*, then

the specimen here described differs from that species in its greater rate of enlargement, its more distinct ventral flattening, and in the conspicuous flattened contact of the connecting rings of its siphuncle along the lower part of the conch, lessening in width of contact toward its top. It differs from the original of Bigsby's figure 2 on the same plate in the much shorter length of its septal necks, and apparently also in its greater rate of enlargement.

It has about the same rate of enlargement laterally as the specimen of *Actinoceras bigsbyi* described by Foerste and Teichert (Jour. Sci. Labs. Denison Univ., 25, pl. 27, figs. 1 A, B, C (1930)), from the Platteville member of the Black River formation at Beloit, Wisconsin, but the sutures of its septa curve less strongly downward ventrally.

73. *Actinoceras billingsi* Sp. nov.

Plate 18, figs. 2A, B

Orthoceras bigsbyi Billings, Geol. Surv. Canada, Geology of Canada, 149, figs. 109a, b (1863).

Specimen 81 mm. long, the lower part of its ventral outline, for a length of 5 camerae, curving in a convex direction with a radius of about 100 mm. The siphuncle enlarges rapidly at the base, but at a diminishing rate farther up, its rate of enlargement above its fifth segment being small. Its lateral diameter at the first five segments is 13.8 mm., 16.5 mm., 19.0 mm., 20.0 mm. and 21.0 mm. increasing to 23 mm. at the eleventh segment. Its dorsoventral diameter along the lower six segments is from 0.5 mm. to 1.0 mm., shorter than the lateral one, but above this level appears to equal the latter. The siphuncle is in contact with the ventral wall of the conch sufficiently to produce lenticular contact areas which vary in lateral diameter from 9 mm. at the second segment to 20 mm. at the sixth segment, and apparently diminishing slightly farther up. The segment at the base of the specimen slopes downward in a ventrad direction at an angle of about 6 degrees with the horizontal, this slope becoming slight along the upper half of the siphuncle. Slightly more than 3 segments of the siphuncle occur in a length equal to their lateral diameter. Where the height of the camerae is 7.2 mm., the annulations of the segments

of the siphuncle are about 21 mm. in diameter, narrowing to 16 mm. at the septal necks, the latter being almost 2 mm. long if measured from the level where the septa adnate to the lower face of the connecting rings slope more strongly downward. The interior of the siphuncle is occupied by an endosiphuncular passage whose center appears nearer the dorsal side of the siphuncle, at least at its lower end. At the fifth segment from the lower end of the specimen the lateral diameter of the conch is estimated at 28 mm., but it is not possible to determine the rate of enlargement of the conch above this point.

Occurrence.—Paquette Rapids, at the lower end of Allumette Island, in the Ottawa River, province of Quebec, Canada; in the Leray member of the Black River formation. No. 1267b, National Museum of Canada.

Remarks.—Among described species, this specimen is related most closely to *Actinoceras glencoense* Foerste and Teichert, from the upper Plattin at Glencoe, Missouri. It differs from the latter in having the segments of the siphuncle in contact with the ventral wall of the conch along a greater number of camerae before their area of contact becomes greatly diminished. The lowest segment preserved is much smaller in diameter, and the ventral outline of the conch is more distinctly curved at the lower end of the specimen.

74. *Actinoceras janesvillense* Sp. nov.

Plate 18, figs. 3A, B

Actinoceras beloitense Clarke, Geol. Minnesota, 3, pt. 2, 782, pl. 47, fig. 18 (1897).

Specimen 65 mm. long, enlarging laterally at an angle estimated at 20 degrees. At its top its lateral diameter is estimated at 64 mm. The ventral side of its cross-section is distinctly flattened, having a radius of curvature of 30 mm., contrasted with that of its ventrolateral sides which is 20 mm. The upper 3 camerae occupy a length of 34.5 mm., and the lower 2 a length of 23 mm., indicating that about 5.5 camerae occurred in a length equal to the lateral diameter of the conch. The sutures of the septa curve downward ventrally about 6 mm. below their level ventrolaterally and ap-

parently curve downward also in a dorsad direction from their ventrolateral elevation, but at a much smaller angle with the horizontal. The concavity of the uppermost septum is at least 10 mm. beneath the lowest level of its suture ventrally. Within the upper 3 camerae the connecting rings are 3 mm. distant from the ventral wall of the conch. The third connecting ring beneath the top has a diameter of 20 mm. The intermediate septal necks contract to 13 mm. As far as can be determined, there is very little difference in the diameter of the siphuncle within the length here preserved. However, since the conch enlarges rapidly, the ratio of this diameter of the siphuncle to the constantly increasing diameter of the conch must become essentially less. Where the length of the camera is 11.5 mm., that of the septal neck is 4 or 5 mm., appearing only a little less than that of the connecting ring. The calcareous deposit lining the interior of the siphuncle has disappeared, and its former location is indicated by a hollow space 2 mm. wide in two of the connecting rings, narrowing to about 0.5 mm. at the septal necks. The central part of the siphuncle, within these calcareous deposits, was filled with matrix after the death of the animal, and this matrix has hardened to rock, now presenting a columnar structure, more or less vertically fluted in an irregular manner, the flutings interrupted by prominent oblique transverse annulations, the latter more or less sharply crested, the crests connected by irregular lamellae with the inner walls of the connecting rings, approximately a little above their mid-height.

Occurrence.—Janesville, Wisconsin; in the Platteville member of the Black River. Original of Clarke's figure 18, cited above. Holotype, no. 8279, in the museum of the University of Minnesota.

Remarks.—This specimen most closely resembles *Actinoceras beloitense*, among the species known so far, in its rate of enlargement, the relative length of the camerae, and the distinct separation of the siphuncle from the ventral wall of the conch. However, its septal necks are much longer, and its connecting rings correspondingly smaller. Moreover, its siphuncle shows very little difference in its diameter within the length preserved, and at a corresponding diameter its distance from the ventral wall of the conch is much less.

75. *Actinoceras cf. libanum* Foerste and Teichert*Plate 19, figs. 1A, B, C*

Cf. *Actinoceras libanum* Foerste and Teichert, Jour. Sci. Labs. Denison Univ. 25, 245, pl. 34, figs. 1 A, B; 2 (1930).

Specimen 64 mm. long, enlarging laterally from a diameter of 27 mm. to 41 mm. in a length of 60 mm. Cross-section, as far as preserved, nearly circular, possibly slightly depressed dorsoventrally. The septum at its base slants downward in a ventrad direction at an angle of 8 degrees with the horizontal, where in contact with the segment of the siphuncle beneath; however, where this segment comes in contact with the lateral walls of the conch this angle is 17 degrees. The third septum above this level forms a horizontal septal neck around the entire circumference of the siphuncle, but on its dorsal side it rises at an angle of 20 degrees with the horizontal, which becomes 15 degrees farther up, along the dorsoventral plane of symmetry. The lowest connecting ring has a dorsoventral diameter of 18 mm., and from this dimension the siphuncle increases regularly in size, the uppermost connecting ring preserved having a diameter of 25 mm. The cross-section of the siphuncle is almost circular, except along the ventral side of the connecting rings which are in flattened contact with the ventral wall of the conch, no doubt producing transverse lenticular contact areas, though the latter are not exposed. The number of camerae in a length of 41 mm. along the upper end of the specimen equals five and a half. There are 3.5 camerae in a length equal to the dorsoventral diameter of the siphuncle, diminishing to 3 camerae at its lower end. Where the length of the camerae is between 7 and 7.5 mm., that of the septal necks slightly exceeds 2 mm., the connecting rings extending outward about 3.2 mm. beyond the most contracted part of the septal necks, the base of these necks being in contact with the septum beneath along an annular area extending outward from the most contracted part of the septal necks for a width of 4 mm. As in other actinoceroids, the deposits on the interior of the siphuncle begin on the septal necks, and envelop these in an annular manner. On vertical section, however, these annuli present a lunate appearance. These

lunate sections grow more strongly upward than downward, so that they meet at a level above mid-height of the connecting rings. In vertical sections the lunar deposits on adjacent septal necks usually are readily distinguishable owing to a thin line of separation, which in some cases is filled with matrix, and which originally probably was occupied by the membrane which formed the deposits. In the specimen at hand, the lower part of the lowest lunar deposit projects beneath the level of lowest septum preserved. The central part of the siphuncle remained free from deposits and formed the endosiphuncle. Later this became filled with matrix. In its present condition this filling of matrix has a diameter of 4 mm. at the base of the specimen, narrows considerably in the overlying 25 mm. and then expands to at least 10 mm. at the top of the specimen. Surface of shell smooth.

Occurrence.—St. Joseph Island, Lake Huron, Ontario, Canada; in the Black River formation. Specimen no. 2821, museum of Univ. of Michigan.

Remarks.—In typical *Actinoceras libanum* the camerae lengthen toward the top and become free from contact with the ventral wall of the conch. The St. Joseph specimen is not preserved for a sufficient length to establish its identity with the Kentucky species.

76. *Actinoceras* sp. (St. Joseph)

Plate 19, fig. 2

Specimen 65 mm. long, enlarging laterally from 33 mm. to 45 mm. in a length of 61 mm. The corresponding dorsoventral diameters are 31 mm. and 40 mm., the upper diameter probably having been shortened by crushing. The number of camerae in a length equal to the lateral diameter equals 5. The sutures of the septa slope downward in a ventrad direction at an angle of about 5 degrees. The concavity of the septa is moderate. At the top of the specimen where its present dorsoventral diameter is 40 mm., the diameter of the septal neck is 19.5 mm. Its outline appears to be circular, and it extends inward from the ventral wall of the conch 4 mm. The crests of the connecting rings, however, are in contact with this ventral wall along transversely lenticular areas. At the base of the specimen the annular area along which the basal

part of the connecting ring is in contact with the septum beneath extends to a point 24 mm. dorsad from the ventral wall of the conch, so that this septum becomes free from this ring about 7 mm. from the dorsal wall of the conch. Here it rises at an angle of 25 degrees with the horizontal. Apparently the size of the siphuncle increases but little in the length of the specimen, but it forms a smaller part of total diameter of the conch farther up.

Occurrence.—St. Joseph Island, Lake Huron, Canada; in the Black River formation. No. 14453, Museum of Univ. of Michigan.

Remarks.—This specimen may belong to the same species as the preceding, but it is not sufficiently well preserved to make this identity certain.

77. *Actinoceras* cf. *bigsbyi* Bronn

Plate 19, fig. 4

Actinoceras bigsbyi Clarke, Geol. Minnesota, 3, pt. 2, 781, pl. 47, fig. 17 (1897).

Orthocerae Bigsby, Trans. Geol. Soc. London, 1, 198, pl. 25, fig. 2 (1824).

Actinoceras bigsbyi Bronn, Leth. Geog., 1, 98, pl. 1, fig. 8 (1837); Foerste, Contrib. Mus. Geol. Univ. Michigan, 2, no. 3, 31, pl. 1, figs. 1 A, B; pl. 12, figs. 7 A, B (1924); Foerste and Teichert, Jour. Sci. Labs. Denison Univ., 25, 231, pl. 27, figs. 1 A-C; pl. 40, fig. 3; pl. 56, figs. 2, 5; pl. 59, fig. 6 (1930).

Specimen 110 mm. long, consisting of two fragments, of which the lower one has been ground flat, both fragments exposing the siphuncle. In its present condition the specimen enlarges laterally from a width of 25 mm. at its base to 36.5 mm. at a point 72 mm. farther up, its rate of enlargement being about 8.5 degrees. However, the specimen does not preserve its entire original width, that being estimated at 35 mm. at the break separating the two fragments. The number of camerae within a length equal to the present width of the specimen varies from slightly less than 4 along the lower half of the specimen to slightly more than 4 toward its top. The crests of the connecting rings of the siphuncle may have been in contact with the ventral wall of the conch, but

this is not definitely known to be the case. The width of these rings increases from 15 mm. at the base of the specimen to 24 mm. at a point 75 mm. farther up. Where this width is 24 mm., the septal necks contract to 16 mm. Here the length of the camerae is 8 mm., while that of the septal necks is 3.5 mm., leaving 4.5 mm. for the length of the connecting rings. The calcareous deposit lining the interior of the siphuncle has crystallized, leaving a central annulated cavity, almost 10 mm. wide at the top of the specimen, narrowing rapidly downward. This annulated cavity now is filled with whitish matrix, its annulations being spaced at intervals corresponding to those between the connecting rings of the siphuncle.

Occurrence.—Garrick's quarry, near Rochester, Minnesota; in the Black River formation. Original of Clarke's fig. 17, on plate 47, cited above. No. 159, in the museum of the Univ. of Minnesota.

Remarks.—This specimen resembles *Actinoceras bigsbyi* in its rate of enlargement and in the relative length of its septal necks compared with the length of the associated connecting rings. Unfortunately it is not known definitely in case of the Minnesota specimen how closely the connecting rings are in contact with the ventral wall of the conch, if at all. Apparently there is such a contact at the seventh connecting ring above the base of the specimen, but the evidence is not clear.

78. *Actinoceras* sp. (Minneapolis)

Plate 19, figs. 3A-E

Actinoceras bigsbyi Clarke, Geol. Minnesota, 3, pt. 2, 781, pl. 47, figs. 15, 16 (1897).

Specimen 30 mm. long, apparently enlarging laterally at an angle of 8 degrees. Its lateral diameter increases from 23 mm. at its base to an estimated diameter of 26 mm. at its top. The corresponding dorsoventral diameters are estimated at 20 mm. and 23 mm. The number of camerae in a length equal to the lateral diameter of the conch is estimated at four and a half. The sutures of the septa slope downward in a ventrad direction at an

angle of almost 10 degrees with the horizontal. The concavity of the uppermost septum is 4 mm. At the base of the specimen the lateral diameter of the connecting ring is 15.5 mm. and that of the overlying septal neck is 11 mm. The lateral diameter of the septal neck at the top of the specimen also appears to be about 11 mm.; however, the lower septal neck is 8.5 mm. from the dorsal wall of the conch, while the upper neck is 12 mm., the conch enlarging rapidly without a corresponding change in the diameter of the siphuncle. The crests of the connecting rings probably were in flattened contact with the ventral wall of the conch for a width of 5 mm., though this part of the ventral side of the conch is not preserved. Where the length of a camera is 6 mm., that of the septal neck is 2.2 mm.

Occurrence.—Minneapolis, Minnesota; in the Black River. Original of Clarke's figures 15, 16, cited above. No. 23, in the museum of the University of Minnesota.

Remarks.—This specimen resembles typical *Actinoceras bigsbyi* in the rate of enlargement of the conch, but it is evident that where its lateral diameter equalled that of the type, the diameter of its siphuncle was much smaller. For the latter, see Jour. Sci. Labs. Denison Univ., 25, pl. 56, fig. 5 (1930).

LEURORTHOCERAS Foerste

Genotype.—*Leurorthoceras hansenii* Foerste. Jour. Sci. Labs.

Denison Univ. 19, 278, pl. 30, figs. 1 A, B; pl. 31, fig. 1; pl. 32, fig. 8, pl. 34, fig. 2 (1921); Foerste and Teichert, 25, 256 (1930).

Conchs evidently closely related to *Actinoceras*, dorsoventrally depressed, with ventral side distinctly flattened. The sutures of the septa are nearly horizontal dorsally, but curve distinctly downward ventrally. The siphuncle is near the ventral side of the conch, but not in contact with the latter. The segments of the siphuncle are approximately globular at their earlier stages of development and become vertically elongated and considerably narrower at later stages. Possibly the segments of the siphuncle at still earlier stages of growth are as nummuloidal as in typical *Actinoceras*, but in no species of undoubted *Actinoceras* so far observed do these segments become as narrow and as strongly elon-

gated for such a long part of the conch as in the species here referred to *Leurorthoceras*.

Leurorthoceras husseyi Foerste closely resembles *Leurorthoceras lebanonense* Foerste and Teichert in the slight convexity of the dorsal vertical outlines of the segments of its siphuncle. However, the cross-section of the conch is much more flattened ventrally.

79. *Leurorthoceras husseyi* Sp. nov.

Plate 20, figs. 1A, B

Holotype 250 mm. long, enlarging laterally from a diameter of 88 mm. at its base to 97 mm. at a point 180 mm. farther up, its apical angle being 4 degrees. At a point where its lateral diameter is 91 mm., its dorsoventral one is 60 mm. The cross-section of the conch is strongly flattened ventrally, its radius of transverse curvature here being approximately 100 mm., changing to 20 mm. laterally, and to 48 mm. dorsally, the dorsal side being evenly, though moderately convex. The number of camerae in a length equal to the lateral diameter of the conch increases from 10.5 along the lower part of the specimen to 15 at its top. Only the basal part of the living chamber, for a maximum length of 20 mm., appears preserved. At the lower end of the specimen 4 camerae occupy a total length of 32 mm.; at mid-length, of 30 mm.; at the top, of only 23 mm. The distinct shortening of the upper 4 camerae, compared with those immediately beneath, indicates that the conch had reached its gerontic stage of growth. Along the dorsal side of the conch the sutures of the septa are almost directly transverse, their slight rise dorsolaterally being due to distortion of the conch by pressure dorsoventrally. Ventrolaterally these sutures curve increasingly downward, forming broad ventral lobes curving downward about 20 mm. beneath their elevation laterally. The concavity of the septa is about 20 mm. compared with their level dorsally. The siphuncle is about 1 mm. distant from the ventral wall of the conch. Its diameter increases from 11 to 13 mm. along the lower half of the specimen. Where its segments have a dorsoventral diameter of 12.5 mm. at mid-height of the camerae, they contract to 11 mm. at the septal necks. These

necks are between 1.5 and 2 mm. in length. Along the dorsal side of the siphuncle, the connecting rings have a convexity of only 1 mm., but ventrally their convexity equals 2.5 mm. at the lower end of the specimen and diminishes thence to 1.8 mm. at mid-length. This difference in convexity of the two sides of the segments of the siphuncle is its most characteristic feature. Along the ventral side of the siphuncle the lower part of the connecting rings is in contact with the underlying septa for an annular width of 3 mm., the free part of the septum here being only about 1 mm. or slightly over. The interior of the siphuncle is filled with matrix which entered as a calcareous mud, but no actinoceroid calcareous deposits are present.

Occurrence.—Cornell, Michigan; in the Trenton formation; in zone 5 and locality 5 of Hussey's studies in this area. No. 14415, Univ. of Michigan. Collected by Prof. Russell C. Hussey.

DEIROCERAS Hyatt

Genotype.—*Orthoceras python* Billings, Geol. Surv. Canada, Rep. Progress for 1853-56, 335 (1857). *Deiroceras python* Hyatt, Proc. Boston Soc. Nat. Hist., 22, 273 (1884).

Conchs with relatively large siphuncles, their segments vertically elongated with elliptical outlines, strongly excentric in location. Interior of siphuncle with typical actinoceroid calcareous deposits.

80. *Deiroceras python* (Billings)

Plate 15, figs. 4 A, B, C

Orthoceras python Billings, Geol. Surv. Canada, Rep. Progress for 1853-56, 335 (1857).

Deiroceras python Hyatt, Proc. Boston Soc. Nat. Hist., 22, 273 (1884).

Deiroceras python Foerste and Teichert, Jour. Sci. Labs. Denison Univ. 25, 292 (1930).

Specimen 66 mm. in length, consisting of 3 segments of the siphuncle. The middle segment is almost 20 mm. long and has a lateral diameter of 21.5 mm. It is assumed that the dorsoventral diameter equalled the lateral one. The septal necks were some-

where between 1.5 mm. and 2 mm. in length, and at these necks the siphuncle is contracted to 14 or 15 mm. The septa were in contact with the basal part of the overlying segments of the siphuncle for a width of at least 2 mm. The siphuncle evidently was strongly excentric in location, probably almost in contact with the ventral wall of the conch. In consequence, the line of contact between the septa and the base of the overlying segments of the siphuncle forms an angle of about 30 degrees with the horizontal. This specimen consists of the calcareous deposit filling the interior of the siphuncle and is actinoceroid in structure. At midheight of each segment of the siphuncle there is an irregular transverse plane along which the calcareous deposits originating at the overlying and underlying septal necks meet, as in all typical actinoceroids. The central tubular passage through this siphuncle is irregular in cross-section and is between 3 and 4 mm. in diameter at the two ends of the specimen. The calcareous deposit within the siphuncle also shows traces of radial structure, but the radial elements are irregular in width and are in contact laterally, differing in this respect from the Actinosiphonata in which they are discrete from each other and strictly lamellar in form.

Occurrence.—Ottawa, Ontario; in the Trenton. No. 1727, in the National Museum of Canada.

Remarks.—Three specimens of *Deiroceras python* are mentioned by Billings in his original description of this species. The first of these came from the Trenton at the City of Ottawa, Ontario; the second was found at the Côte des Neiges, Montreal, Quebec; and the third was found in limestone near the surface in concession 14 of the Indian Lands, in Kenyon township, Ontario.

Neither of the first two specimens described by Billings can be found. The specimen here described agrees apparently in the form of its segments with the uppermost or twenty-seventh segment of the first specimen described by Billings, the latter having a diameter of 11 lines (23.3 mm.) where its length is 1 inch (25.4 mm.). Unfortunately Billings stated that the passage of this siphuncle through the septa was small, while in the specimen at hand it should be called large, its diameter being 14 or 15 mm., as already stated.

81. *Deiroceras remotiseptum* (Hall)

Plate 16, fig. 2

Ormoceras remotiseptum Hall, 3rd ann. Rept. New York State Cab. Nat. Hist., 173, pl. 4, fig. 3 (1850).

Type 115 mm. long, enlarging in diameter from 43.5 mm. at its base to 48.5 mm. at a point 80 mm. farther up, indicating an angle of enlargement of 3.7 degrees. The specimen includes 5 camerae, the upper 4 occupying a total length of 86 mm., or slightly more than 2 camerae in a length equal to the diameter of the conch. The sutures of the septa slant downward in a ventrad direction at an angle of about 10 degrees with a directly transverse or horizontal plane. The concavity of the septa equals 8 or 9 mm. Where the diameter of the conch is 48 mm. that of the siphuncle is 23 mm., narrowing to 13 mm. at the septal necks. The septa come in contact with the lower part of the segments of the siphuncle at a distance of 3 or 4 mm. from the most contracted part of the septal necks, and are adnate to these segments for a corresponding annular width. There is a distinct central endosiphonal tube 2 mm. in diameter, which is remarkably equal in size for a length of over 3 camerae. This endosiphonal tube is 34 mm. distant from the median part of the dorsal side of the conch. From this it is estimated that the siphuncle was only 1 or 2 mm. distant from the ventral wall of the conch. The matrix contains numerous valves of *Sowerbyella* and a single valve of some brachiopod, possibly referable to *Hohltedahlna*.

Occurrence.—Watertown, New York; in the Trenton formation. Holotype, no. 12241, New York State Museum.

82. *Deiroceras scofieldi* Sp. nov.

Plate 16, figs. 1 A, B

Actinoceras remotiseptum Clarke, Geol. Minnesota, 3, pt. 2, 782, pl. 54, figs. 1-3 (1897).

Specimen 360 mm. long, all belonging to the phragmacone. The latter enlarges dorsoventrally from a diameter of 48.5 mm. at its base to 74 mm. at a point 320 mm. farther up, indicating an apical angle of 4.5 degrees. The number of camerae within a

length equal to the diameter of the conch averages slightly over 2, but locally may be as low as 2. The sutures of the septa slope slightly downward in a ventrad direction, but otherwise appear almost straight. Where the dorsoventral diameter is 60 mm., the concavity of the septum equals about 14 mm. Where this diameter is 50 mm., the maximum diameter of the siphuncle is 18 mm., and its ventral wall is 2 mm. from the nearest part of the ventral wall of the conch. At the septal necks the siphuncle contracts to about 12 or 13 mm. From their dorsal or ventral sides the segments of the siphuncle appear elongated elliptical, but from a lateral point of view they appear strongly oblique, owing to their strongly excentric location and the deep concavity of the limiting septa. The interior of the siphuncle is occupied by characteristic actinoceroïd deposits, with traces of an endosiphuncle, and of lateral branches at a level slightly above midheight of the camerae. There are no indications of surface ornamentation on the few traces of the shell remaining.

Occurrence.—Cannon Falls, Goodhue County, Minnesota; in the Platteville member of the Black River. No. 4132, in the Scofield collection of the University of Minnesota.

Remarks.—Compared with the type of the species described by Hall from the Watertown member of the Black River at Watertown, New York, under the name *Ormoceras remotiseptum*, the siphuncle of the Minnesota species here described is much less contracted at the septal necks, and its segments are relatively narrower compared with their length. In the type of the New York species, however, the diameter of these segments equals their length, and their constriction at the septal necks is much shorter and more conspicuous.

83. *Deiroceras kindlei* Sp. nov.

Plate 15, figs. 3 A, B

Specimen 90 mm. long, enlarging at an angle of 7 degrees from a diameter of 22 mm. at its base to approximately 31 mm. at its top. Its cross-section is circular. The number of camerae in a length equal to the diameter of the conch varies from 4 at the lower end of the specimen to 3 at its upper end. The sutures of

the septa incline only slightly downward in a ventrad direction. Where the diameter of the conch is 30 mm., the center of the siphuncle is located 6.5 mm. from the ventral wall of the conch, and it enlarges from 4.4 mm. at the septal necks to 10 mm. at mid-height within the camerae. The height of the camerae here is 10 mm. The segments are oblique, owing to the strongly excentric location of the siphuncle and the considerable concavity of the septa, the latter equalling at least 5 mm. The connecting rings extend 2.5 mm. toward the center of the conch from a vertical line connecting the dorsal side of the inner margin of successive septal necks, and 4 mm. ventrad of the vertical line connecting the ventral margin of these necks. This, together with the oblique form of the segments gives the latter the peculiar form characteristic of the various species recently referred to the genus *Deiroceras*. The septal necks are nearly 1 mm. long, both ventrally and dorsally. The lower part of the dorsal outline of each segment meets the underlying septum at an angle of about 80 degrees, while the corresponding angle on its ventral side is approximately 25 degrees. The surface of the shell apparently was smooth.

Occurrence.—St. Joseph Island, in the northwestern part of Lake Huron; in the Black River. Holotype, no. 14418, in the Museum of the University of Michigan.

Remarks.—*Deiroceras kindlei* belongs to the group of species including *Deiroceras nashvillense*, *Deiroceras capitulense*, and *Deiroceras curdsvillense*. Of these, it is nearest *Deiroceras nashvillense*, which at a corresponding diameter has 3 instead of 4 camerae in a length equal to the diameter of the conch.

84. *Deiroceras paquettense* Sp. nov.

Plate 15, figs. 2 A, B, C

Specimen 80 mm. long, circular in cross-section, its upper half enlarging from 23 mm. to 26.3 mm. in a length of 37 mm., indicating an apical angle of 5 degrees. Slightly over 3 camerae occur in a length equal to the diameter of the conch. Where the diameter of the conch is 22.5 mm., the center of the siphuncle is 5 mm. from the ventral wall, its septal neck is 3 mm. in diameter, and the segments of the siphuncle attain a diameter of 6 mm. at midheight.

Where the diameter of the conch is 27 mm., the concavity of the septum is 3.5 mm., and the center of the siphuncle is 6 mm. from the ventral wall. On lateral view the segments of the siphuncle appear strongly oblique, conforming to the course of the septa in their vicinity, the location of this siphuncle being strongly excentric. The sutures of the septa appear nearly directly transverse ventrally.

Occurrence.—Paquette Rapid, at Allumette Island, on the Ottawa River, Canada; in the Leray member of the Black River. No. 6840, in the National Museum of Canada.

Remarks.—On lateral view the segments of this siphuncle resemble those of *Deiroceras curdsvillense* Foerste and Teichert, their ventral outline being distinctly more convex than their dorsal one, especially along their upper half. However, the sutures of the segments of the Kentucky species curve strongly downward ventrally.

This species may possibly be identical with *Orthoceras pertinax* (Billings). However, as the structure of the siphuncle of that species is not known definitely, it appears preferable to assign a distinct name to the specimen here described, at least provisionally.

85. *Deiroceras pertinax* (Billings)

Plate 15, figs. 1 A, B

Orthoceras pertinax Billings, Canadian Naturalist and Geologist, 5, p. 175 (1860).

Specimen 62 mm. long, enlarging laterally from a diameter of 14.1 mm. at its base to 19.5 mm. at a point 57 mm. farther up. The cross-section of the conch is circular. The number of camerae in a length equal to the diameter of the conch is 3. The sutures of the septa curve slightly downward laterally and have a general slight downward slant in a ventrad direction. At the base of the specimen the suture curves downward 1 mm. laterally and its ventral part is about 1 mm. lower than its dorsal part. The siphuncle is located ventrad of the center of the conch. The septum at the base of the specimen is pierced by a small opening 1.5 mm. in diameter, the center of this opening being 4 mm. from the ventral wall of the conch where the diameter of the latter is 14

mm. A similar opening appears to have been present at the immediately overlying septum, but all the overlying septa are pierced by large openings varying from about 4 mm. at the lower end of the specimen to 6 mm. at its top. On closer inspection it becomes evident that the supposed septa consist in reality of siliceous replacements of the calcareous deposits that once lined the upper and lower faces of the septa. On the upper side of the second septum above the base of the specimen the passage through this septum appears to spread in an upward direction, but only a short length of this spreading part is preserved. It is possible that the segments of the siphuncle enlarged within the camerae sufficiently to attain a diameter of 4 mm., as stated by Billings in his original description of this species, but this can not be determined with confidence from the specimen at hand, at least in its present condition. The surface of the silicified shell appears vertically ribbed, but this evidently is due to weathering. On one of the ventrolateral sides there are traces of 4 ribs in a width of 7 mm. where the circumference of the conch is estimated at 53.4 mm. The ribs vary in width from about one millimeter to distinctly less than a millimeter. Possibly the surface of the shell originally was vertically color-banded, the banded area occupying almost half of the circumference of the conch, and apparently being confined to its ventral side. In that case about 14 vertical color-bands originally may have been present.

Occurrence.—Paquette Rapids, Allumette Island, Ottawa River, Quebec; in the Leray member of the Black River formation. Holotype; no. 1276, National Museum of Canada.

Remarks.—Possibly the segments of the siphuncle enlarged somewhat as in *Deiroceras curdsvillense* Foerste and Teichert, from the lowest Trenton at Curdsville, Kentucky. It is here tentatively referred to the genus *Deiroceras*.

GONIOCERAS Hall

Genotype.—*Gonioceras anceps*.—Pal. New York, 1, 54, pl. 14, figs. 1 a-d (1847).

Conch lenticular in cross-section, with its ventral side slightly convex or almost flat; its dorsal side is distinctly more convex,

though even here the convexity is relatively small. The lateral parts or wings of these dorsal and ventral sides usually are less convex than the central or body parts of the conch. The cross-sections of these wings is sharply angular at the lateral margins of the conch. The sutures of the septa curve strongly downward along the body part of the conch, but arch strongly upward in crossing the dorsal and ventral faces of the wings, the lateral terminations of these sutures being considerably lower than the tops of the saddles formed on the two faces of the wings. The siphuncle is nearer the ventral wall of the conch. Its segments are low and broadly nummuloidal in structure, though the size of the siphuncle is moderate compared with the width of the entire conch. The deposits within its interior are clearly actinoceroïd.

86. *Gonioceras kayi* Foerste

Plate 23, fig. 1

Gonioceras kayi Foerste, Jour. Sci. Labs. Denison Univ., 24, 319, pl. 46, fig. 2 (1929).

Specimen 20 mm. long, including 6 camerae in a length of 18 mm. along the median part of this ventral side. The ventral side of its cross-section has a convexity of only 2 mm., while that of its dorsal side equals at least 11 or 12 mm. The siphuncle here is 12 mm. in diameter and is circular in cross-section. It appears to be about equally distant from both the dorsal and ventral sides of the conch, but this is not certain. Both the dorsal and the ventral parts of the cross-section become concave about 5 mm. from the lateral margins of the conch, converging at an angle of 20 mm. in the immediate vicinity of these margins. The camerae near the top of the specimen are 3 mm. in length medially, narrow to 1.8 mm. where they rise along the inner side of the lateral ventral saddles, have an average height of 3 mm. at the top of these saddles, and curve thence abruptly outward and downward in a diagonal direction. The septa are only moderately concave in a dorsoventral direction.

Occurrence.—Mineral Point, Wisconsin; in the Platteville member of the Black River, No. 8298, in the museum of the University of Minnesota.

Remarks.—This specimen corresponds to the lower 6 camerae of the holotype, cited above, the latter being described from Allamakee county, Iowa.

87. *Gonioceras occidentale* Hall

Plate 23, figs. 3, 4, 2

Gonioceras occidentale Whitfield, Mem. Amer. Mus. Nat. Hist., 1, pt. 2, p. 72, pl. 12, fig. 2 (1895); Foerste, Jour. Sci. Labs. Denison Univ., 24, 316, pl. 46, fig. 1 (1929).

The type of this species, from Platteville, Wisconsin, was described and figured in the publications cited above. A few additional details are provided by the specimens described here.

Mineral Point specimen.—Specimen 54 mm. long, estimated to have had a total lateral diameter of 68 mm. at its base. The immediately overlying ten camerae occupy a total length of 20 mm. when measured along the median part of the conch. The following series of ten occupies a length of 21.8 mm. The crests of the lateral ventral saddles are 42 mm. from each other at the base of the specimen. These crests are relatively broader and less geniculate than in typical *Gonioceras kayi* Foerste. At its base the cross-section of the conch is similar to that of the species just named. Its ventral part has a convexity of 2 mm. medially, that of its dorsal side being 11 mm. The siphuncle here is 2 mm. from the ventral wall of the conch; its lateral diameter is 9 mm. and its dorsoventral diameter is 7 mm. Originally these two diameters may have been equal, the dorsoventral diameter having been shortened by pressure after the death of the animal. The segments of the siphuncle resemble relatively thin disks, with convex vertical outlines. The septa are distinctly concave in a dorsoventral direction, both along the median or body part of the conch and along its lateral wings.

Occurrence.—Mineral Point, Wisconsin; in the Platteville member of the Black River formation. No. 2861, Univ. of Michigan. (Pl. 23, fig. 3.)

Dixon specimen.—Specimen 60 mm. long, enlarging laterally at an angle of 50 degrees. Of this total rate of enlargement the axial or body part occupies 32 degrees, while each of the lateral or

wing parts occupies 16 degrees. The axial part enlarges from a lateral diameter of 31 mm. to 45 mm. in a length of 32 mm. Counting downward from the point where the lateral diameter of this axial part is 45 mm., there are 23.5 camerae in a length of 45 mm., when counted along its median line. At the upper point mentioned the lateral diameter of the siphuncle is 12 mm. The sutures of the septa curve evenly downward across the axial part of the conch and become crowded laterally where the downward curvature of the axial lobes of these sutures changes into the upward curvature of the lateral saddles. At midlength of the specimen the total downward curvature of these lobes, beneath the crests of the lateral saddles, equals 15 mm. Where the sutures are crowded they rise at an angle of 25 degrees with the horizontal. Along their lateral saddles the sutures arch evenly upward, but curve downward at the margin of the conch to a point lower than the lowest part reached by their axial lobes. The surface of the specimen is badly weathered, but it is assumed that the side of the conch exposed is the dorsal one, or the one whose cross-section is more convex in a lateral direction.

Occurrence.—Dixon, Illinois; in the Platteville member of the Black River formation. No. 46527, U. S. National Museum. (Plate 23, fig. 4.) *Gonioceras occidentale* Clarke, Geol. Minnesota, 3, pt. 2, 795, pl. 57, fig. 6 (1897).

Minneapolis specimen.—Specimen about 50 mm. long, with cross-section closely similar to that of *Gonioceras occidentale* and *Gonioceras kayi*, but only the median or body part of the conch is preserved, its lateral parts or wings being broken off. Where the median part of the body of *Gonioceras occidentale* has 10 camerae in a length of 20.5 mm., the corresponding part of the Minnesota specimen has only 8 camerae. In other respects, however, their ventral appearance is closely similar. At the top of the specimen, where its dorsoventral diameter is 13 mm., the siphuncle appears almost in contact with the ventral wall of the conch, but 4 mm. distant dorsally. Along its lower part the siphuncle is 10 mm. in diameter and is circular in outline. There is a central vertical endosiphuncle, at present represented by the cast of its interior, which is 2.5 mm. wide and 1 mm. thick dorsoventrally. From

this endosiphuncle tubules branch outward radially, as in typical *Actinoceras*.

Occurrence.—Minneapolis, Minnesota; in the Platteville member of the Black River formation. No. 5113, Univ. of Minnesota. (Plate 23, fig. 2.) *Gonioceras anceps* Clarke, Geol. Minnesota, 3, pt. 2, pl. 57, fig. 5 (1897).

Remarks.—Large and well preserved specimens of typical *Gonioceras anceps* from the Watertown member of the Black River formation at Watertown, New York, show that the angle of lateral enlargement of the conch is much larger near the smaller end of the conch than at later stages of growth, the lateral margins becoming more nearly subparallel at gerontic stages. In some specimens the axial part reaches a lateral diameter of 70 mm. at the base of the living chamber. On account of this variation at different stages of growth, different species are not readily comparable except at the same stages of growth.

The Dixon specimen, described above, closely resembles that part of typical *Gonioceras anceps* which corresponds to it in size, but the camerae are more crowded, and there is a difference in the course of the sutures of the septa along the lateral saddles.

LAMBEOCERAS FOERSTE

Genotype.—*Gonioceras lambii* Whiteaves, Trans. Royal Soc. Canada, 9, pt. 4, 86, pl. 11, figs. 1 a, b (1892); *Lambeoceras lambi* Foerste, Jour. Cincinnati Soc. Nat. Hist., 22, 45 (1917); Jour. Sci. Labs. Denison Univ., 24, 213, pl. 34, fig. 1; pl. 39, fig. 1 (1929).

Conch strongly depressed dorsoventrally, cross-section lenticular, with its dorsal outline slightly more convex. Lateral angles rather narrowly rounded. Sutures of the septa curving strongly downward ventrally and dorsally, curving moderately outward on approaching the lateral angles of the conch. Siphuncle near the ventral wall of the conch. Septal necks curving strongly downward, inner part of the upper side of the connecting rings subparallel to these necks. Similar structures of the siphuncle are shown by *Lambeoceras princeps* Troedsson, *L. nudum* Troedsson, *L. magnum* Troedsson, and *L. boreum* Troedsson. *Lambeoceras*

cultratum Miller and *Lambeoceras peculiare* Miller have been described recently from the Lander sandstone member of the Big-horn formation. The two specimens from Putnam Highland, in the southwestern part of Baffin Land, recently referred by Foerste to *Gonioceras*, probably belong to *Lambeoceras*, later collections by Soper having proved its undoubted occurrence in neighboring parts of Baffin Land.

88. *Lambeoceras confertum* Sp. nov.

Plate 24, fig. 2

Triptoceras lambi Clarke, Geol. Minnesota, 3, pt. 2, 793, pl. 56, figs. 1, 2 (1897).

Lambeoceras cf. *lambi* Foerste, Jour. Sci. Labs. Denison Univ., 24, 321, pl. 47, fig. 1 (1929).

Two specimens of *Lambeoceras* from the Stewartville dolomite were figured by Clarke from the exposures at Stewartville, Minnesota. One of these retained the lower part of a living chamber to which the upper 18 camerae of the phragmacone still were attached. The second includes 12 camerae and the lateral parts of a thirteenth. At the time the first specimen was refigured and redescribed, the second could not be found. It has since been located and proves to have been the specimen used by Clarke for his figure 2, cited above. As there indicated, it retains a trace of the siphuncle, and further study suggests that this siphuncle is distinct from that of typical *Lambeoceras lambi* (Whiteaves) in structure. Hence this second specimen, undoubtedly belonging to the same species as the first specimen figured by Clarke, is described here.

Specimen 95 mm. long; originally about 100 mm. in diameter laterally at its top, enlarging at an angle of 13 degrees. At present the dorsoventral diameter of the specimen is 27.5 mm., but its ventral surface is weathered sufficiently to expose the siphuncle and originally this diameter may have been 30 mm. The cross-section of the conch is lenticular, with its lateral angles narrowly rounded. The number of camerae in a length of 100 mm. slightly exceeds 14. The sutures of the septa curve downward about 27 mm. ventrally, curving slightly outward within about 10 mm. of

their lateral terminations. The septa curve only slightly in a dorsoventral direction, and their sutures are slightly lower in location ventrally than dorsally. At the base of the seventh camera from the top, the specimen is broken along one of the septa and exposes the siphuncle, the passage of the latter through the septum apparently being 6 mm. in diameter, as in Clarke's figure 2, cited above; however, the actual diameter of the septal neck may be less since the septal neck is not clearly defined here. At the third camera from the top of the specimen one of the segments of the siphuncle is exposed for a width of 9 or 10 mm. where the length of the camera is somewhere between 6.5 mm. and 7 mm. This suggests that the segments of the siphuncle of the Stewartsville species are much less broadly nummuloidal than those of typical *Lambeoceras lambi*, from the Selkirk member of the Red River formation.

Occurrence.—Stewartsville, Minnesota; in the Stewartsville dolomite. No. 8293A, in the museum of the University of Minnesota.

Remarks.—The separation of the Stewartsville species from the Manitoban genotype is based entirely on the smaller width of the segments of its siphuncle. However, it also should be noted that there is no trace of a strong downward curvature of the septa at the septal necks, as in typical *Lambeoceras lambi*. Evidently the structure of the siphuncle of the Stewartsville specimen needs further elucidation beyond the fact that its segments are not as broad as those of the genotype.

Among the species of *Lambeoceras* described by Troedsson from Cape Calhoun, on the northwestern coast of Greenland, the septal necks of two of these species present an anomalous appearance. In *Lambeoceras princeps* and *Lambeoceras nudum* the lower face of the septum apparently has been thickened by a calcareous deposit extending as far inward and downward as the lower margin of the septal neck, where it fills in the angle between the septal neck and the inner margin of the connecting ring. This results in an appearance as though the upper margin of the connecting ring came in contact with the outer side of the septal neck along a sharp annular ridge. Additional studies of the septal necks of species of *Lambeoceras* are desirable.

89. *Lambeoceras* cf. *nudum* Troedsson*Plate 24, fig. 1*

Cf. *Lambeoceras nudum* Troedsson. On the middle and upper Ordovician faunas of Northern Greenland, pt. I, Cephalopods, Jubilaeumsekspeditionen Nord om Grønland 1920-23, no. 1, p. 47, pl. 17, figs. 3, 4; pl. 22 (1926).

Specimen about 50 mm. long, along its median part; including 7 camerae within this length. Lateral diameter about 93 mm. Sutures of septa curving downward ventrally about 29 mm., curving slightly outward on approaching the lateral outlines of the conch.

Occurrence.—Nettiling Lake, Southern Baffin Land; in the equivalent of the Red River formation. Collected by J. Dewey Soper. No. 6841, National Museum of Canada.

BARRANDEOCERAS Hyatt

Genotype.—*Nautilus natator* Billings, Canadian Naturalist, 4, no. 6, 406 (1859). *Barrandeoceras natator* Hyatt, Proc. Boston Soc. Nat. Hist., 22, 299 (1884); Whiteaves, Geol. Surv. Canada, Pal. Foss., 3, pt. 4, 308, pl. 39, figs. 1, 1a, 1b, (1906); Ruedemann, Bull. New York State Mus., No. 90, 454, pls. 32, 33 (1906).

Conch with volutions in contact with each other, but without any dorsal contact area. Cross-section strongly compressed laterally, with the ventral side more narrowly rounded than the dorsal one. Volutions enlarging at a more moderate rate than in typical *Plectoceras*. Sutures of septa strongly curved downward laterally, forming dorsal and ventral saddles. Siphuncle located slightly ventrad of the center of the conch; segments curved tubular, not enlarging within the camerae. Surface of shell costated at earlier stages of growth, the costae curving distinctly upward dorsolaterally and then strongly downward in a ventrad direction, indicating a deep hyponomic sinus. Parallel to these costae there are low and broad growth lines, the latter being the sole ornamentation of the shell at later stages of growth.

CENTROCYRTOCERAS Foerste

Genotype.—*Cyrtoceras annulatum* Hall, Pal. New York, 1, 194, pl. 41, figs. 4 a-d, 5 (1847); *Cyrtoceras subannulatum* D'Orbigny, Prodr. Pal., 1, 1 (1849). *Centrocyrtoceras subannulatum* Foerste, Jour. Sci. Labs. Denison Univ. 21, 366, pl. 45, figs. 4a-c (1926).

Conchs small, strongly curved, cross-section circular; sutures of septa directly transverse; location of siphuncle slightly ventrad of the center of the conch, segments of siphuncle nearly cylindrical. Surface of shell distinctly annulated, the annulations either directly transverse or curved downward slightly along the median part of its lateral side. In addition to annulations there are also transverse raised lines, parallel to the annulations.

Cyrtoceras bondi Safford and *Gyroceras duplicostatium* Whitfield are similar to *Centrocyrtoceras* in the location and structure of the siphuncle and in the course of their annulations, but their conchs are compressed laterally.

90. Centrocyrtoceras subannulatum (D'Orbigny)

Plate 28, figs. 8 A, B

Cyrtoceras annulatum Hall (not Goldfuss), Pal. New York, 194, pl. 41, figs. 4 a-d, 5 (1847).

Cyrtoceras subannulatum D'Orbigny, Prodr. Pal., 1, 1, (1849).

Centrocyrtoceras subannulatum Foerste, Jour. Sci. Labs. Denison Univ., 21, 366, pl. 45, figs. 4A-C (1926).

Selected type.—In the absence of the original of Hall's figure 4a, the original of his figures 4b, c, d is selected here as the type. This specimen is 15 mm. long and its convex ventral outline curves with a radius of about 12 mm. Its dorsoventral diameter enlarges from 4.5 mm. at its base to 6 mm. at its top. Its cross-section is approximately circular. There is no trace of a siphuncle either at its top or at its base, but originally a trace may have been present. The conch is crossed by relatively prominent transverse annulations, of which 5 occur in a length equal to the diameter of the conch at the top of the specimen, this number decreasing apparently to 4.5 camerae at its lower end. Only the left side of the

conch is exposed, and on this side the annulations curve slightly downward along its median part. The most prominent annulations are approximately a third of a millimeter in elevation. From 4 to 5 transverse striae occupy a length of half a millimeter when counted within the grooves between the annulations. On the crests of the latter they occur at about the same rate. Under cross-illumination there are also traces of much finer longitudinal raised lines. Plate 28, fig. 8B.

The original of Hall's figure 5, from the same locality, and presumably from the same horizon, is 21 mm. long and its convex ventral outline curves with a radius of 18 to 20 mm. Its lateral diameter enlarges from 8.8 mm. at its base to 13 mm. at its top. A little above mid-length its cross-section is circular. There are about 7 or 7.5 annulations within a length equal to the diameter of the conch at the top of the series counted. These annulations have a maximum height of one third of a millimeter. Compared with the transverse striae on the preceding specimen, those on the latter are much finer and more distant, 7 occurring in a length of 2 mm. No traces of longitudinal striae can be detected. The difference in the relative number of transverse striae present suggests the possibility that this second specimen belongs to a distinct species, but in other respects it sufficiently resembles the one here selected as a type of *Centrocyrtoceras subannulatum* to be interpreted as merely the more enlarged mature part of another individual. Plate 28, fig. 8A.

Occurrence.—Middleville, New York; in the Trenton. Specimens numbered 821 in the American Museum of Natural History.

91. *Centrocyrtoceras* cf. *subannulatum* D'Orbigny

Plate 28, figs. 2 A, B

Specimen 35 mm. in length, measured along its convex ventral outline. The radius of curvature of this outline increases in length from 8 mm. along the lower third of the conch to 15 mm. farther up. Its dorsoventral diameter enlarges from 2.4 mm. at its base to 8.5 mm. at the top of the conch. The cross-section of the conch is circular. The length of the camerae is indicated only along the lower part of the specimen where its diameter is 3 mm.,

and here 4 camerae occur in a length equal to the diameter. Farther up, the relative number of camerae may be larger. The concavity of the septum at the top of the specimen is 1 mm. The siphuncle here is 0.7 mm. in diameter and its center is 2.9 mm. from the ventral wall of the conch, the diameter of the latter being 8.5 mm. Slightly over 7 annulations occur in a corresponding length at the top of the specimen. On the left side of the specimen, if held with the ventral side facing away from the observer, the annulations are almost straight, curving only faintly downward laterally, though rising gently in a ventrad direction. Along the middle part of its right side, however, these annulations curve more abruptly downward. There is no trace of transverse striae, parallel to the annulations, as in typical *Centrocyrtoceras subannulatum*. However, the shell has been replaced by silica in such a manner that its finer surface features may not be preserved.

Occurrence.—Paquette Rapids, 65 miles northwest of Ottawa, Ontario, Canada; in the Leray member of the Black River. Specimen no. 6842, National Museum of Canada.

92. *Centrocyrtoceras relaxum* Sp. nov.

Plate 28, fig. 4

Holotype closely similar to the Paquette Rapid specimen here referred tentatively to *Centrocyrtoceras subannulatum* in its nearly circular cross-section and in its ornamentation, but its lengthwise curvature is distinctly less at the same stage of growth. The radius of curvature of its convex ventral outline is 15 mm. along its lower half, increasing to 20 mm. farther up. Its dorsoventral diameter enlarges from 4 mm. at its base to 8.7 mm. at its top. The lateral compression of the conch is faint, its lateral diameter equalling 8.5 mm. at the top of the specimen. Here 6.5 annulations occur along a length equal to the diameter of the conch. With the ventral side facing away from the observer, the annulations curve more distinctly downward on the right side of the conch, than on its left side, with a tendency toward angularity along the median line of this side. The sutures of the septa appear straight, but rise in a ventrad direction. The concavity of the septum at the top of the specimen is small, the passage of the

siphuncle here is 0.6 mm. in diameter, and its center is 3 mm. from the ventral wall of the conch, the dorsoventral diameter being 8.7 mm.

Occurrence.—Murfreesboro, Tennessee; in the Murfreesboro limestone. No. 48409, U. S. National Museum.

Remarks.—Typical *Centrocyrtoceras subannulatum* (D'Orbigny), as occurring in the Trenton of New York, is known only from a few small fragments, insufficient to give a clear idea of the amount of its curvature and the rate of its enlargement. It will be noted that figures 8 A and 8 B, on plate 22 of this publication, differ considerably in their rate of enlargement. Under these circumstances it is impossible to make an exact comparison between the Murfreesboro species here described and the typical New York species.

93. *Centrocyrtoceras* (?) *percinctum* Sp. nov.

Plate 28, figs. 9 A, B

Holotype 34 mm. long, measured along its convex ventral outline. The radius of curvature of this ventral outline increases from 10 mm. along its lower three-fourths to 15 mm. farther up. Its dorsoventral diameter increases from 4.2 mm. at its base to 8 mm. at its top. Its cross-section is circular. The camerae are not distinctly delineated. Several sutures of septa at irregular intervals curve slightly downward laterally, and rise moderately in a ventrad direction. The location of the siphuncle can not be determined, hence the reference of this holotype to the genus *Centrocyrtoceras* is only tentative. The surface of the conch is sharply and conspicuously annulated, 3 annulations occurring in a length equal to the diameter at the lower end of the specimen, increasing to 3.6 annulations at its top. Here the annulations are 0.5 mm. in height, and less than one millimeter in width, the intervening grooves being almost 2 mm. wide. The crests of the annulations are approximately 0.5 mm. wide. In addition there are very faint transverse raised lines, about 5 in a length of 1 mm. Along the upper part of the conch the median part of the shell is weathered into a shallow vertical groove 0.8 mm. in width. Traces of similar bands occur also ventrolaterally and laterally, their total number

equaling 5 in a total width of almost 10 mm. The spaces between the vertical grooves are about 1.5 mm. wide. Since these vertical grooves apparently are the results of weathering, it is possible that they locate former vertical color bands, similar to the color bands of some orthoconic cephalopods. The crests of the annulations appear to be nodulated, 5 nodules occurring in a width of 5 mm. along the ventral side of the upper annulations.

Occurrence.—Murfreesboro, Tennessee; in the Murfreesboro limestone. No. 48407, U. S. National Museum.

94. *Centrocyrtoceras bondi* (Safford)

Plate 28, figs. 1; 3A, B

Cyrtoceras bondi Safford, Geol. Tennessee, 290, pl. 4 (G.3), figs. 3a-d (1869).

Plectoceras bondi Grabau and Shimer, North Amer. Index Fossils, 2, 73 (1910).

The specimen figured by Safford has been lost, but another specimen from the same locality and horizon is here selected as a topotype.

Specimen 170 mm. long, measured along the convex ventral outline of the conch. Form of coiling gyroceran, the apical end missing, but apparently not in contact with the dorsal side of the conch one volution farther up, though close to the latter. Above the point of nearest approach of the later part of the conch to this apical end, the upper part of the conch continues to curve, but diverges strongly from the earlier formed part of the conch, the total length of the specimen equalling about one and a fourth volutions. The radius of curvature of the convex ventral outline increases from 20 mm. at the lower half of the first volution preserved to 50 mm. along that part of the conch extending beyond the original apical end of the conch. The dorsoventral diameter increases from 8 mm. at the lower end to 18 mm. half a volution farther up, and to 29 mm. at the top of the specimen. Where its dorsoventral diameter is 28 mm., its lateral diameter is estimated at 25 mm. The uppermost septum extends to within 30 mm. of the top of the conch along its ventral outline. The concavity of

this septum is 5 mm. and it rises more strongly ventrally than dorsally. The camerae are not clearly defined, and the siphuncle is poorly exposed. The surface of the shell is conspicuously annulated, the annulations curving downward laterally, and showing a tendency toward angularity along the median part of this curvature on the left side of the conch. Along the lower part of the conch, for a length of 45 mm., most of the grooves between the annulations are evenly concave, but several grooves show traces of single secondary annulations confined to the ventral side of the conch. Farther up these secondary annulations occur more frequently. Where the dorsoventral diameter of the conch is 11 mm., four annulations occur in a corresponding length. At a diameter of 16 mm., there are also 4 primary annulations. In addition to the annulations there are narrow transverse lines, about 4 in a length of 1 mm. Plate 28, fig. 1.

Occurrence.—Cliff on Stones River, west of Murfreesboro, Tennessee; in the Murfreesboro member of the Stones River division of the Chazyan. No. 87117, U. S. National Museum; topotype.

In a specimen belonging to Vanderbilt University, 28 mm. long along its ventral outline (Plate 28, figs. 3 A, B), the dorsoventral diameter enlarges from 12 mm. to 17 mm., the corresponding lateral diameters being 11 mm. and 15 mm. Where its dorsoventral diameter is 17 mm., the center of the siphuncle is 5.5 mm. from the ventral wall of the conch, and its passage through the septum here is 1.6 mm. in diameter. The primary transverse ribs number 4 in a length equal to the dorsoventral diameter, and extend entirely around the circumference of the conch, though becoming weak dorsally. The secondary ribs usually number only 1 between two successive ribs, but in one case the primary rib is doubled along its ventral side, and in another case one of the secondary ribs is doubled. The secondary ribs become faint or obsolete on the dorsal half of the conch. The primary ribs tend to be angulate along the median part of their downward curvature on both of the lateral sides of the conch. In a second specimen, of equal size and length, the siphuncle is seen to be cylindrical. The sutures curve downward laterally, but rise strongly in a ventrad direction. In consequence they intersect the transverse ribs

at a conspicuous angle. About 4.5 camerae occur in a length equal to the dorsoventral diameter, where the latter is 17 mm. These two specimens are labelled as coming from Cannon county. Lithologically their appearance and their stratigraphical origin is that of the Murfreesboro limestone.

95. *Centrocyrtoceras vicinum* Sp. nov.

Plate 28, figs. 6 A, B

Holotype differing from *Centrocyrtoceras bondi* in its greater lateral compression, more rapid rate of enlargement dorsoventrally, and the more numerous primary ribs, all of the ribs, as far as known, being primary. If secondary ribs were present, these can not be detected at present, owing to subsequent crystallization of the specimen.

Holotype 27.5 mm. long on its dorsal outline, the radius of curvature of its convex ventral outline being 20 mm. Its dorsoventral diameter enlarges from 8.7 mm. near its base to 13.5 mm. at a point 20 mm. farther up. The corresponding lateral diameters are 7 mm. and 11 mm. The sutures of the septa curve only slightly downward laterally, but they rise strongly in a ventrad direction. The camerae are not delineated. The center of the siphuncle is 6 mm. from the ventral margin of the uppermost septum, the dorsoventral diameter of the latter being 14 mm. The transverse ribs are approximately of equal size, and in the present condition of the specimen are weak both ventrally and dorsally. They curve only slightly downward laterally. Where the dorsoventral diameter of the conch is 13 mm., there are 8 ribs in a corresponding length.

Murfreesboro, Tennessee; in the Ridley member of the Stones River division of the Chazyan. No. 48406, U. S. National Museum.

96. *Centrocyrtoceras ridleyense* Sp. nov.

Plate 28, figs. 5 A, B, C, D

Holotype differing from *Centrocyrtoceras vicinum* chiefly in its more numerous transverse ribs, there being 11 in a length equal

to the dorsoventral diameter where the latter is 13 mm. All of these ribs are uniform in size and are relatively inconspicuous.

Radius of curvature of its convex ventral outline, 20 mm. Dorsoventral diameter enlarging from 9.5 mm. at its base to nearly 14 mm. at its top. The corresponding lateral diameters are 8.8 mm. and 11 mm. The suture of the septum at the top of the specimen curves only slightly downward laterally but rises strongly in a ventrad direction. The center of the siphuncle is located 5.8 mm. from the ventral wall of the conch where its dorsoventral diameter is 14 mm. Plate 28, fig. 5 D.

Occurrence.—Murfreesboro, Tennessee; in the Ridley member of the Stones River division of the Chazy. No. 48408, U. S. National Museum. Holotype.

An additional specimen, belonging to Vanderbilt University apparently belongs to the same species. It is labelled as coming from Woodbury, Cannon county, Tennessee, and came either from the Ridley member or from the Lebanon member of the Stones River division of the Chazy. It is 90 mm. long, measured along its convex ventral outline. The radius of curvature of this outline increases from 12 mm. along the lower 30 mm. of its length to 20 mm. along the following 30 mm., and to 30 mm. along its upper 30 mm. The uppermost septum preserved is 70 mm. above the lower end of the specimen, the living chamber being at least 20 mm. long. The dorsoventral diameter of the conch enlarges from 4 mm. at its base to 9 mm. at a point 30 mm. farther up, to 14 mm. after an additional interval of 30 mm., and to 18 mm. at the top of the specimen. At the top of the phragmacone, where the dorsoventral diameter is 16 mm., the lateral diameter is estimated at 12 mm. The suture of the uppermost septum curves downward about 1 mm. laterally, and rises only moderately higher ventrally than dorsally. The center of the siphuncle here is 6.5 mm. from the ventral wall of the conch, and the diameter of its passage through the septum is 1.4 mm. At a dorsoventral diameter of 16 mm. there are 12 strongly raised transverse lines in a corresponding length along the ventral outline of the conch. At a diameter of 12 mm. there are 11 transverse raised lines. Locally there are traces of intermediate transverse lines.

97. *Centrocyrtoceras filosum* Sp. nov.*Plate 28, figs. 11 A, B*

Holotype differing from the species described on the preceding pages chiefly in the absence of distinct annulations on the surface of its shell, their place being taken by very narrow transverse bands or striae. The banded appearance is produced when the upper margin of the striation is abruptly delineated, but the lower side of the striation slopes much more gradually downward from the crest of the striation toward the upper margin of the striation next beneath, apparently invaginating beneath the latter. Where the diameter of the conch is 17 mm., there are 8 bands in a length of 9 mm., followed by 13 narrower bands in the following length of 9 mm., when counted along the ventral outline of the conch. Along the median part of the opposite one of the lateral sides there are 16 transverse striae in a length of 9 mm.

Holotype 39 mm. long, on its ventral outline, the radius of curvature of this outline being 30 mm. The dorsoventral diameter enlarges from 13 mm. at its base to 18 mm. at its top, the corresponding lateral diameters being 12 mm. and 15.5 mm. The septum at the top of the specimen rises strongly in a ventrad direction, its downward curvature laterally being slight. Where the dorsoventral diameter of the conch is 18 mm. the center of the siphuncle is about 7.5 mm. from the ventral wall of the conch and its passage through the septum is 1.3 mm. in diameter.

Occurrence.—Murfreesboro, Tennessee; in the Ridley member of the Stones River division of the Chazyan. No. 87036, U. S. National Museum.

98. *Centrocyrtoceras americanum* (D'Orbigny)

Lituities convolvans (Hisinger), Hall, Pal. New York, 1, 53, pl. 13, fig. 2a (1847).

Hortholus americanus D'Orbigny, Prodr. de Pal., 1, 1 (new name for *Lituities convolvans* Hall) (1849).

Barrandeoceras subcostulatum Whiteaves, Ottawa Naturalist, 12, 121 (1898); Geol. Surv. Canada, Pal. Foss., 3, 310, pl. 38 (1906).

Conchs gyroceran at all stages of growth. In one specimen the apical end of the conch is 1 mm. distant from the dorsal side of the next following volution, this interval increasing to 2 mm. at one and four-fifths volutions from this end. Beyond this, the conch uncoils rapidly, but does not become straight at any stage of growth. One specimen has a total length of two and a fifth volutions, including the living chamber. In the specimen mentioned first the dorsoventral diameter of the conch enlarges from 1.5 mm. at its apical end to 29 mm. at the end of the second volution, all belonging to the phragmacone. In a third specimen, the dorsoventral diameter at the top of the specimen is 31 mm., and the living chamber is at least 30 mm. long. In a fourth specimen the living chamber appears to be 90 mm. long, when measured along its convex outline; at least, that is the length above the distinctly camerated part of the conch. Where the dorsoventral diameter of the conch is 33 mm., the lateral diameter is 25 mm. The dorsal and ventral parts of the cross-section are about equally convex. Where the dorsoventral diameter of the conch is 17 mm. there are 4.5 camerae in a corresponding length; at a diameter of 24 mm. there are 6 camerae; and at a diameter of 30 mm. there are 7 camerae. The sutures of the septa curve downward laterally about 6 mm. where the dorsoventral diameter of the conch is 33.5 mm. The curvature of the septa in a lateral direction is relatively slight. The center of the siphuncle here is 13 mm. from the ventral outline of the conch. Where the dorsoventral diameter of the conch is 29 mm., the diameter of the siphuncle is 2 mm. The septal necks here are 0.6 mm. long. The connecting rings are much thinner, and are essentially cylindrical, varying from this occasionally to faintly convex or even faintly concave. Their upper margins are continuous with the sharp edge at the base of the septal necks, and their lower margin invaginates slightly into the top of the neck beneath. The shell is half a millimeter thick along the dorsal side of the conch along the upper portion of the phragmacone. Its surface is crossed by relatively coarse transverse striae, at least along the lower part of the conch, for a length of one and a quarter volutions from its apical end. Along the last quarter of the first volution there are 4 more prominent transverse

ribs in a length equal to the dorsoventral diameter of the conch, between which there are one or two less coarse transverse raised lines.

Occurrence.—Watertown, New York, in the upper part of the Black River formation. No. 59429, U. S. National Museum; five specimens.

99. *Centrocyrtoceras vagrans* (Billings)

Plate 35, figs. 1, 2

Gyroceras (*Lituites*) *vagrans* Billings, Geol. Surv. Canada, Rep. Progress for 1853-56, 308 (1857).

Barrandeoceras vagrans Whiteaves, Geol. Surv. Canada, Pal. Foss., 3, pt. 4, 311, pl. 40, figs. 1, 1a, 2, 2a (1906).

Gyroceracone enlarging from a dorsoventral diameter of 2.2 mm. at its smaller end to 26 mm. at the top of the uppermost camera preserved, the interval being 177 mm. when measured along its ventral outline. Above this level the conch continues for a length of 33 mm. when measured along its dorsal side. Near the larger end of the specimen about 5 camerae occur in a length equal to the dorsoventral diameter. The sutures of the septa curve downward laterally about 4 mm., and their ventral parts rise about 5 mm. above their dorsal ends. Below the lowest camera preserved, where the dorsoventral diameter of the specimen is about 16 mm., there is a tubular structure, about 12 or 13 mm. long and 1.3 mm. in diameter, which may represent the siphuncle, but this is not certain. Its center is located 5 mm. from the ventral outline of the specimen in its present condition. Plate 35, fig. 1.

Occurrence.—La Petite Chaudiere, in the Ottawa River, just above Ottawa, Ontario, Canada; in the Black River formation. Holotype; no. 1300, National Museum of Canada.

A second specimen, from the same locality and formation, shows a closely similar gyroceraconic type of coiling. Almost two volutions are preserved, and the uppermost septum is located about 22 mm. from top of its dorsal outline. Found at La Petite Chaudiere, Tetreauville, in Quebec, opposite Ottawa. No. 1300a, in the National Museum of Canada. Plate 35, fig. 2.

100. *Centrocyrtoceras* (?) *whiteavesi* Sp. nov.

Cyrtoceras sinuatum Whiteaves, Pal. Foss., 3, pt. 4, 312, pl. 40, figs. 3, 3a (1906).

The original of the specimen figured by Whiteaves is lost, but the published figures are sufficient to indicate its distinctness from *Cyrtoceras sinuatum* Billings, the latter being interpreted as a species of *Zitteloceras* (Plate 21, figs. 7 A, B), with a conspicuous ventral hyponomic sinus, and with much shorter camerae. The relative narrowness and depth of this hyponomic sinus suggests that the siphuncle was located close to the ventral wall of the conch. In the specimen figured by Whiteaves, however, the siphuncle is 8 mm. from the ventral wall of the conch where the dorsoventral diameter of the latter is 24 mm. Moreover, the form of this siphuncle is evenly tubular, instead of consisting of a series of obliquely oval and vertically elongated segments. The course of the transverse ribs or annulations is peculiar in its sinuosity, curving faintly downward dorsally, then rising in a ventrad direction to a point beyond the median line of its lateral side, and finally curving moderately downward ventrally. In this respect it differs from typical *Centrocyrtoceras*, in which the transverse ribs curve downward laterally.

From typical *Barrandeoceras* this specimen differs in the location of the maximum upward curvature of its transverse ribs ventrad of the median line of its lateral side, while in typical *Barrandeoceras* their maximum upward curvature is distinctly dorsad of this median line (Pal. Foss., 3, pt. 4, pl. 39, fig. 1a). Moreover, in typical *Barrandeoceras* these transverse ribs are figured as becoming vague ventrally, and possibly also dorsally. The generic relationship of this specimen, therefore, remains uncertain.

This specimen was 58 mm. long on its ventral convex outline. The radius of curvature of this outline was 30 mm. along the greater part of the length of the conch, increasing to 35 mm. at its top. Its dorsoventral diameter increased from 17.5 mm. at its base to 26 mm. at a point 40 mm. farther up on its ventral outline. Five camerae occurred in a length equal to the dorsoventral diameter. The concavity of the septa equaled 7 mm., and their su-

tures rose strongly in a ventrad direction along the upper end of the phragmacone. The transverse ribs were relatively narrow, and were separated by much broader grooves.

Occurrence.—La Petite Chaudiere, opposite Ottawa, on the Quebec side of the Ottawa River; in the Black River.

COMMENSAL WORMS IN CONCHS OF *CENTROCYRTOCERAS*

Plate 28, figs. 4, 5 B, 6 A, 11 B

In four species of *Centrocyrtoceras* there is a tubular passage near the median line of one of the lateral sides of the conch, just beneath the shell, so that it is exposed by the weathering away of the latter. This tubular passage is excluded from contact with the interior of the camerae by a thin layer of shell, originally probably calcareous. This structure is best preserved in the holotype of *Centrocyrtoceras filosum* (Plate 28, fig. 11 B), in which the tube is exposed along the entire length of the specimen, on the right side of the conch, when its ventral side is directed away from the observer. The encysting tube is preserved both at the lower and at the upper end of the specimen. The diameter of the tube is approximately 1 mm. At its base the tube apparently retains some matrix. In the holotype of *Centrocyrtoceras vicinum* (Plate 28, fig. 6A) similar conditions prevail. The greater part of the length of the tubular passage is occupied by matrix, its diameter being 2 mm. in its present condition. In *Centrocyrtoceras ridleyense*, one specimen (Plate 28, fig. 5B) exposes one of these tubular passages on the left side of the specimen, a second specimen exposing a similar passage on its right. In the holotype of *Centrocyrtoceras relaxum* (Plate 28, fig. 4) there appears to be a similar tubular passage, exposed only near the top of the right side of the specimen. The siphuncle in all of these species is tubular, and located moderately ventrad of the center of the conch.

Aside from the wall surrounding the vertical tubular passages along the median part of the lateral side of these conchs, separating the same from the interior of the camerae, there is no other structure present. In the absence of any direct knowledge of the

origin of these tubes they may be imagined as produced by worms entering the living chamber of the conch between the body of the animal and the inner wall of the shell. The same membrane which exuded the material building up the shell of the conch apparently surrounded this worm by a calcareous lining, similar to that forming the shell. In the absence of any knowledge of the anatomy of the living animal formerly occupying these conchs, the idea that these worms may have been commensal in their habits is only a guess.

Blake, in his *British Fossil Cephalopoda*, pt. 1, 164, pl. 16, figures a similar tubular passage in *Orthoceras* (*Tretoceras*) *bisiphonatum* Sowerby. His figure 3a suggests a conch 88 mm. in diameter, with the center of the siphuncle 21 mm. from the ventral wall of the conch. The tubular passage is 13 mm. in diameter, and is located in contact with the ventral wall of the conch, directly ventrad of the siphuncle. His fig. 3b presents a lateral view of one segment of the siphuncle, almost globular in form. His figure 3 shows both the lateral view of the tubular passage as seen from the ventral side of the conch, and also the lower end of the siphuncle. Regarding this tubular passage Blake stated that it appears to have had a separate sheath on the inside, as it is not marked in any way by the septa. He regarded this passage as a backward prolongation of the body chamber, with something like muscular impressions at its distal end.

In the *Geology of Anticosti*, by W. H. Twenhofel (Memoir 154, Geol. Surv. Canada, 266, pls. 31, 32, 33 (1927)) a similar structure is described in the case of *Polygrammoceras chicottense* by Foerste. The location of the cylindrical passage with reference to the siphuncle and the ventral wall of the shell is shown by figure 2 on plate 33. Both the siphuncle and the tubular passage are shown by the figure on plate 32. Of the siphuncle 4 segments are exposed. Figure 2 on plate 31 shows how the septa curve downward on approaching the walls of the tubular passage.

Possibly the decurrent sutures of septa noted on the lateral sides of certain specimens of *Phragmoceras* and of *Cyrtorizoceras* may be connected with similar tubular passages just within the shell of the conch. (*Jour. Sci. Labs. Denison Univ.* 25, 123, pls. 5, 18,

21 (1925.) However, no tubular passages have been detected so far in any specimens belonging to these genera.

PAQUETTOCERAS Gen. nov.

Genotype.—*Paquettoceras allumettense* Foerste

Conch resembling *Centrocyrtoceras* in its lengthwise curvature, rate of enlargement, and in the location of the siphuncle slightly ventrad of the center of the conch. It resembles the more typical forms of the latter also in its circular cross-section. It differs from that genus, however, in the absence of transverse ribs. Only the genotype is known at present, and this occurs in the Black River formation.

101. *Paquettoceras allumettense* Sp. nov.

Plate 28, fig. 10

Specimen 62 mm. in length along its convex ventral outline. The radius of curvature of this outline increases from 20 mm. along its lower half to 30 mm. farther up. Its dorsoventral diameter enlarges from 7 mm. at its base to 14 mm. at a point 38 mm. farther up, and to 17 mm. at its top. Its lateral diameters are similar, the cross-section of the conch being circular. At the top of the specimen, 5.5 camerae occur in a length equal to the dorsoventral diameter when counted along their ventral outline. The sutures of the septa are straight, but rise distinctly from the dorsal toward the ventral side of the conch. The concavity of the septum at the top of the specimen is 3 mm. The diameter of the siphuncle here is 1.3 mm. and its center is 5.8 mm. from the ventral wall of the conch, the dorsoventral diameter of the conch being 17 mm. The segments of the siphuncle enlarge slightly within the camerae, the enlargement taking place on the ventral side of the siphuncle, no corresponding enlargement being observed along the dorsal outline of these segments. The surface of the shell apparently was smooth.

Occurrence.—Paquette Rapids, on the southeastern side of Allumette Island, about 65 miles northwest of Ottawa, on the Ottawa River, Canada. In the Leray member of the Black River. Holotype, no. 7227, in the National Museum of Canada.

WHITFIELDOCERAS Gen. nov.

Genotype.—*Oncoceras mumiaforme* Whitfield, Geol. Wisconsin, 4, 232, pl. 7, figs. 3-5 (1882).

Conchs relatively small, enlarging moderately as far as the base of the living chamber and then contracting toward the aperture. Lengthwise curvature small, the ventral outline usually slightly convex except near the top of the phragmacone and along the lower part of the living chamber where this convexity usually is distinctly greater. The dorsal outline usually is faintly concave along the greater part of the phragmacone, but often is faintly convex along the upper part of the phragmacone and the lower part of the living chamber, though sometimes this dorsal gibbosity is practically obsolete. Cross-section circular, or slightly depressed dorsoventrally. Siphuncle small, located a short distance ventrad of the center of the conch; its segments more or less moniliform. This subcentral location of the conch is one of the characteristic features of the genus.

102. Whitfieldoceras mumiaforme (Whitfield)

Plate 32, figs. 1 A, B, C; 2 A, B; 3; 4

Oncoceras mumiaforme Whitfield, Ann. Rep. Geol. Surv. Wisconsin for 1879, 58 (1880); Geol. Wisconsin, 4, 232, pl. 7, figs. 3-5 (1882).

Clinoceras mumiaforme Hyatt, Proc. Boston Soc. Nat. Hist., 22, p. 282 (1884); Clarke, Geol. Minnesota, vol. 3, pt. 2, p. 797, pl. 57, fig. 7, 10 (1897).

The specimens figured by Whitfield have been lost, but the figures published by him give the following information.

Larger specimen about 38 mm. long, conspicuously curved lengthwise, its convex ventral outline having a radius of curvature of approximately 45 mm. The lower part of its dorsal outline evidently was correspondingly concave, but the upper part of the phragmacone and the lower part of the living chamber are conspicuously convex for a length of 20 to 25 mm., with the maximum convexity about 7 or 8 mm. below the base of the dorsal side of the living chamber. The radius of curvature of this dorsal gib-

bosity is about 30 to 35 mm. The dorsal outline of the living chamber is distinctly concave on the cast of its interior, but probably was much less concave along the surface of the shell itself. The dorsoventral diameter of the specimen enlarges from 6 mm. at its base to 12 mm. at its most gibbous part, diminishing to 11 mm. at the base of the living chamber, and to 8 mm. at the aperture. The corresponding lateral diameters are similar, as though the cross-sections were circular, except at the aperture, where the lateral diameter is distinctly greater than the dorso-ventral one. The cast of the interior of the living chamber is distinctly contracted at mid-length, its dorsoventral diameter diminishing from 11.5 mm. at its base to 7 mm. at mid-length, and then increasing to 8 mm. at the aperture. Along the lower part of the specimen figured by Whitfield, 4 camerae occupy a length of 11.5 mm., while at the top of the phragmacone of the same specimen approximately 5 camerae occur in the same length. The uppermost camera is scarcely half as long as the immediately underlying camerae, indicating that the conch had reached the gerontic stage of its growth. The sutures of the septa incline distinctly downward in a ventrad direction, especially near the top of the phragmacone. The siphuncle is central in location, and, at the base of the specimen, is about 1 mm. in diameter.

Occurrence.—Below Carpenter's quarry, at Beloit, Wisconsin. In the Lower Buff or Platteville member of the Black River.

The species occurs at this horizon also at the tunnel 3 miles south of Belleville, at Argyle, and at Gratiot, in Wisconsin; at Dixon, Illinois; and at Rochester, and Minneapolis, in Minnesota.

In the absence of the specimen described and figured by Whitfield, a specimen in the U. S. National Museum (No. 25320), from the Tunnel 3 miles south of Belleville, Wisconsin, is selected as a type. This specimen is 42 mm. long, 17 mm. of this length belonging to the living chamber. Its ventral outline has a radius of convex curvature of 60 mm. along the phragmacone and the lower part of the living chamber, the length of this radius increasing moderately along the upper part of this chamber. The lower part of the dorsal outline is faintly concave, the middle part being slightly convex or gibbous from a point 10 mm. below the base of

the living chamber to a point 7.5 mm. above this base. Here the curvature of the dorsal side reverses to concave, the concave part of this outline occupying the upper two-thirds of the length of the living chamber. This concavity extends around the entire circumference of the cast of the interior of the chamber, being produced by a broad annular thickening of the shall on its interior. As a result of this annular thickening there is a constriction along the upper third of the cast of the interior of the chamber above which the chamber appears to expand toward the aperture. The lateral diameter of the cast of the interior of this conch enlarges from 7 mm. at its base to 12 mm. at the second camera beneath the living chamber, diminishes to 10 mm. at 5 mm. above the base of this chamber, and to 8 mm. at 10 mm. above this base, expanding to 9 mm. at the aperture. The cross-section of the phragmacone is circular along its lower part, becoming slightly depressed dorsoventrally at its top. Where the diameter of the conch is 10 mm., 4 camerae occupy a corresponding length; this is true also at a diameter of 12 mm. The upper two camerae are slightly shorter (Plate 32, figs. 1 A, B). A separate living chamber (Plate 32, fig. 1C) 18 mm. long, shows a slight concavity along the lateral outline of the surface of the shell, the concavity of the corresponding part of the cast of its interior being greater. In both specimens the passage of the siphuncle through the septa is 1 mm. in diameter, and its location is central.

Another typical specimen (No. 48370, U. S. National Museum), 30 mm. long and 1.5 mm. in diameter, presents a well preserved outline along the dorsal side of the conch, showing the gibbosity along the dorsal side of the upper part of the phragmacone and the lower part of the living chamber better than the Belleville specimen described above. It was obtained at Beloit, Wisconsin. Both specimens are from the Platteville member of the Black River.

The specimen figured by Clarke (Geol. Minnesota, 3, pt. 2, pl. 57, fig. 10 (1897)), is 61 mm. long, 15.5 mm. of this length belonging to the living chamber, the total length of the latter not being preserved. Clarke figured only the lower part of this specimen, the entire specimen as far as preserved being shown by figure 4 on

plate 26 of the present publication. Its ventral outline is distinctly convex, while its dorsal outline is almost straight. The cross-sections of the conch are almost circular or faintly depressed. The sutures of the septa slant slightly downward in a ventrad direction. Where the dorsoventral diameter of the conch is 12 mm. the center of the siphuncle is located 6.8 mm. from the ventral wall. Immediately below this level 3 segments of the siphuncle occupy a total length of 6 mm., the diameter of these segments apparently enlarging from 1.33 mm. at their septal necks to 2.3 mm. at midlength, their form being approximately globular; however, only the dolomitized casts of the interior of these segments appear to be preserved. Found by Prof. Charles Schuchert, four miles north of Beloit, Wisconsin, and preserved in the museum of the University of Minnesota. Plate 32, fig. 4. No. 4127, Univ. of Minnesota.

The living chamber of a specimen from Janesville, Wisconsin, was figured by Clarke in the *Geology of Minnesota*, as cited above. His figure 7 presents a ventral view. Its lateral diameter decreases from 10.5 mm. at its base to 7.5 mm. at mid-length, and then increases to 9 mm. at the aperture. The dorsoventral diameter at its base is 10 mm. The suture of the septum at its base slopes downward in a ventrad direction at an angle of 5 degrees with the horizontal. The siphuncle is central in location and its diameter is scarcely 1 mm. at its passage through the septum at the base of the chamber. No. 4125, in the museum of the University of Minnesota. Plate 32, fig. 3.

Three living chambers, from Mineral Point, Wisconsin, are in the museum of the University of Michigan, and are there numbered 2830 and 14425. The best preserved of these is 21 mm. long on its ventral outline, and its lateral diameter decreases from 11.5 mm. at its base to 7.8 mm. at a point 11 mm. farther up; it next increases to 9 mm. at 5 mm. farther up, and then continues at the last diameter as far as the aperture, which is at least 3 mm. farther. A similar extension of the upper part of the living chamber into a short cylindrical section is shown by a second specimen in the same group. These specimens show also a slight dorsoventral depression of the conch at the base of the living chamber,

the maximum difference being shown by the third of the group here described, in which the lateral diameter is 12 mm., while the dorsoventral one is 10.3 mm., the depression taking place chiefly on its dorsal side. Plate 32, figs. 2 A, B.

103. *Whitfieldoceras clarkei* Sp. nov.

Plate 32, fig. 5

Clinoceras mumiaeforme Clarke, Geol. Minnesota, 3, pt. 2, 797, pl. 57, figs. 8, 9 (1897).

Specimen 66 mm. long, slightly curved lengthwise. Along its concave dorsal outline, the maximum concavity equals only 1 mm., the lower 34 mm. of its length being almost straight. The lower part of its ventral outline, for a length of 40 mm., is also nearly straight, but above this level, for a length of 15 mm., it curves convexly with a radius of 60 or 70 mm. Its dorsoventral diameter enlarges from 3.5 mm. at its base to 10 mm. at a point 46 mm. farther up, and then diminishes to 9 mm. at a point 17 mm. farther, above which it appears to enlarge faintly. Along the greater part of the length of the specimen its cross-section appears circular, but at the level of its maximum dorsoventral diameter this cross-section probably is slightly depressed. At the break 20 mm. above its base, the interior of the conch is filled with crystalline calcite. At its base, the concavity of the septum equals half a millimeter. The septal foramen here is 0.3 mm. in diameter, and its location is central. The surface of the shell is almost smooth, but under a lens low and closely crowded transverse striae are visible, which are straight but rise slightly in a ventrad direction.

Occurrence.—From some unknown locality and horizon in Minnesota, possibly from the Decorah member of the Black River No. 4126, in the collection of Dr. Robbins, in the museum of the University of Minnesota.

Remarks.—Compared with the figures of the original types of the species described by Whitfield under the name *Clinoceras mumiaeforme*, the Minnesota specimen here described is much less curved lengthwise but appears humped at the top of the phrag-

macone. The upper part of the dorsal outline of its phragmacone and of the adjacent part of the living chamber is only faintly gibbous.

104. *Whitfieldoceras exiguum* (Billings)

Plate 9, figs. 6 A, B

Cyrtoceras exiguum Billings, Canadian Nat. Geol., 5, 172, figs. 17-18 (1860).

The types of this species can not be found. However, the two figures published by Billings, with the accompanying description, are sufficient to indicate that this species is closely similar to that described by Whitfield under the name *Oncoceras mumiaforme*, differing chiefly in its much smaller size.

According to Billings's figure 17, cited above, the larger one of the cotypes was 26 mm. long, and the radius of curvature of its convex ventral outline was about 50 or 55 mm. Its dorsoventral diameter enlarged from 4 mm. at the base of the specimen to 8 mm. at a point 27 mm. farther up, and then decreased to 5.5 mm. at a point 6 mm. farther up, and to 6 mm. at the aperture. Up to 27 mm. above its base, the ventral outline of the conch was quite evenly convex, contracting above this level both dorsoventrally and laterally to within 2 or 3 mm. of the aperture, above which it expanded slightly. Along the lower part of the specimen its dorsal outline was slightly concave, but became gibbous farther up, its maximum gibbosity being 27 mm. above its base. It is not known definitely where the top of the phragmacone was in this specimen. The suture at the base of the specimen sloped downward in a ventrad direction.

In Billings's figure 18 cited above, the maximum lateral diameter of the specimen is 8 mm. and is located 10 mm. below the aperture. The uppermost suture of a septum is located 3 mm. farther down, where the diameter is only slightly less. Here 4 camerae occur in a length of 8 mm. Neither specimen retains any trace of the siphuncle.

Occurrence.—Near L'Original, 52 miles east of Ottawa, south of the Ottawa River, in Ontario; in the Trenton limestone.

Remarks.—This species evidently occurs at a considerably higher horizon than the species described 20 years later by Whitfield, under the name *Oncoceras mumiaforme*.

105. *Whitfieldoceras* cf. *exiguum* (Billings)

Plate 32, figs. 9 A-D

Oncoceras exiguum Clarke. Geol. Minnesota, 3, pt. 2, 798, pl. 58, figs. 10, 11 (1897).

Six specimens from the Trenton of Minnesota are at hand, five from Fountain, including the two figured by Clarke, and one from Bell Creek, in Goodhue County. None of these is preserved well enough to identify it definitely with the species described by Billings from the Trenton at L'Original, in Ontario, Canada, under the name *Cyrtoceras exiguum*. The specimen (A) illustrated by figure 10 of Clarke, cited above (Plate 32, fig. 9A), has a living chamber 12.5 mm. in length, with a maximum diameter of 7.3 mm. about 2 mm. above the base of this chamber, contracting to 6.1 mm. at 9 mm. above its base. The only well preserved suture of a septum is that at the base of the living chamber. The original (B) of Clarke's figure 11 (Plate 32, fig. 9B) retains only 8.5 mm. of the length of the living chamber and has a maximum diameter of 7 mm. at the base of the latter. In descending order, the length of the underlying camerae is 0.65 mm., 1.35 mm., 1.7 mm., and approximately 1.5 mm. The specimen is strongly compressed laterally, due to pressure after the death of the animal. A third specimen (C), plate 32, fig. 9D, has a maximum diameter of 6.8 mm. Of the living chamber a length of 6.5 mm. is preserved. In descending order the underlying camerae have a length of 0.3 mm., 1.1 mm., and 1.4 mm., the septum at its base having a concavity of 1 mm., and the septal foramen of the siphuncle having a diameter slightly greater than 0.5 mm. The location of this siphuncle is central. A fourth specimen (D), plate 32, fig. 9C, has a maximum diameter of 5.8 mm., and preserves 3.5 mm. of the length of the living chamber. The length of the underlying camerae in descending order is 1.3 mm., 1.4 mm., and 1.6 mm., the underlying camerae being estimated at 1.5 mm.

The single specimen from Belle Creek (F) has a maximum diam-

eter of 5.4 mm., and retains a length of 6.8 of the living chamber. Its uppermost camera is 0.9 mm. long, the next is 1.35 mm., the suture at the base of the third camera from the top of the phragmacone not being distinctly preserved.

Occurrence.—Fountain, Minnesota, and Belle Creek, in Goodhue county, Minnesota; in the Prosser member of the Trenton. In the museum of the University of Minnesota. Plate 32, figs. 9A, C are numbered 8281, and figs. 9B, D are numbered 4114.

Remarks.—None of these specimens is sufficient in length to show clearly the rate of lengthwise curvature of the conch, nor its total length, though specimens D and F apparently did not attain a length of even 25 mm. The central location of the siphuncle in specimen C suggests their relationship to the genus here called *Whitfieldoceras*; but there is a possibility that, if well preserved specimens were at hand, these would prove distinct specifically from the species described by Billings.

106. *Whitfieldoceras trentonense* Sp. nov.

Plate 32, figs. 6, 7 A, B; 8

Compared with the figures of *Whitfieldoceras exiguum* published by Billings, the specimens of *Whitfieldoceras* occurring in the Trenton of New York are more elongate and are much less curved lengthwise.

The specimen represented by figs. 7 A, B, on plate 32 is selected as a holotype. It is 34 mm. long and preserves the shell. Its convex ventral outline has a radius of curvature of 100 mm. along the lower 17.5 mm. of its length, and then changes to a radius of 50 mm. to within 7 mm. of the aperture, where it becomes faintly concave. The dorsal outline is almost imperceptibly concave along its lower half, reaching its maximum gibbosity at 18 mm. above its base, with another, almost imperceptible, concave curvature farther up. Its lateral diameter enlarges from 5 mm. at its base to 8 mm. at a point 19 mm. above its base, and then decreases to 7.5 mm. at a point 6 mm. farther up, retaining the same diameter until close to the aperture, where it enlarges slightly. The cross-section of the conch is slightly depressed dorsoventrally at its most gibbous part. The surface of the shell is almost smooth,

the transverse striae being visible only under a lens. A second specimen from the same locality (fig. 6 on plate 32) is 45 mm. long and exposes its ventral side. Its dorsal side apparently is almost straight. These specimens are from Watertown, New York, in the Trenton formation. They are numbered 59492, and 59493 respectively in the U. S. National Museum.

A much smaller specimen (fig. 8 on plate 32), from the Trenton at Trenton Falls, New York, is 37 mm. long and only 6 mm. in diameter at its maximum diameter. It also exposes its ventral side, and appears to have been nearly straight dorsally. No. 59494, U. S. National Museum.

A closely similar specimen, 34 mm. long, with a maximum diameter of 8 mm., was obtained near Poland, in Herkimer county, New York. It is labelled as coming from the upper part of the Black River. No. 59491, U. S. National Museum.

107. *Whitfieldoceras baffinense* Sp. nov.

Plate 32, figs. 11 A, B; 12 A, B; 13 A, B

Conchs closely similar to *Whitfieldocera trentonense*, but differing in their greater enlargement along the upper part of the phragmacone and the lower part of the living chamber. In consequence, the lower part of the phragmacone tapers more rapidly toward its apical end, and the living chamber narrows more conspicuously at midlength. In one specimen (Plate 32, figs. 12 A, B), 37 mm. long, the lateral diameter increases from 4.5 mm. at its base to 9.3 mm. at a point 19 mm. farther up, then decreases to 8 mm. at 11 mm. still farther up, retaining this diameter to the top of the specimen. The specimen is depressed dorsoventrally by pressure subsequent to the death of the animal, its maximum diameter in this direction being only 7 mm. In its present condition the radius of curvature of its convex ventral outline is 80 mm. Its dorsal outline is faintly concave along midlength of the phragmacone and also along midlength of the living chamber, being slightly gibbous along the upper part of the phragmacone and the basal part of the living chamber. Where the lateral diameter is 6 mm. there are 3 camerae in a corresponding length; at 8 mm. there are almost 4 camerae; and at 9 mm. there are 4.5 camerae. The

upper two camerae are successively shorter than those immediately beneath. A second specimen (Plate 32, figs. 11 A, B), 33 mm. long, and with a maximum lateral diameter of 10 mm., also is strongly depressed dorsoventrally. Along the upper part of the phragmacone and the lower part of the living chamber the ventral side of the conch is crushed in for a width of 7 mm. and a length exceeding 14 mm., the central part of the depression equaling at least 2 mm. beneath the former ventral outline of the conch. The remarkable feature is that the shell of the conch here is bowed inward as though it consisted of a thick, tough membrane, instead of being abruptly cracked, as in a stiff brittle shell. A third specimen (Plate 32, figs. 13A, B), 20 mm. long, includes the lower half of a living chamber and the upper part of a phragmacone. It also is strongly depressed dorsoventrally. The lower part of a phragmacone, 17 mm. long, almost 6 mm. in diameter at its upper end, here exposes the siphuncle at the center of the conch, its passage through the septum being almost half a millimeter in diameter. It is assumed that the diameter of this siphuncle enlarges within the camerae.

Occurrence.—Head of Frobisher Bay, southeastern Baffin Land, Arctic; in strata identified by Charles Schuchert as Trenton. No. 28199, U. S. National Museum.

LOGANOCERAS Gen. nov.

Genotype.—*Cyrtoceras regulare* Billings, Geol. Surv. Canada, Rept. of Progress for 1853–56, 314 (1857.)

Conch strongly curved lengthwise, relatively small, circular in cross-section. Sutures either straight or curving but slightly downward laterally, rising at an increasing rate in a ventrad direction on approaching the upper end of the phragmacone. Siphuncle close to the ventral wall of the conch, segments apparently scalariform along their dorsal outlines. The margin of the aperture shows no trace of a hyponomic sinus. The surface of the shell is smooth.

This genus includes *Loganoceras regulare* Billings, *Loganoceras massasaugaense*, and *Loganoceras paquettense*. The relationship of the specimen from St. Joseph Island, here doubtfully referred

to *Loganoceras paquettense*, is uncertain. The surface of the shell is not preserved, and there is a possibility of this specimen belonging to *Zitteloceras*.

108. *Loganoceras regulare* (Billings)

Plate 25, figs. 1 A, B; 2 A, B

Cyrtoceras regulare Billings, Geol. Surv. Canada, Rept. of Progress for 1853-56, 314 (1857).

Specimen 70 mm. long when measured along its ventral outline, strongly curved lengthwise, the radius of curvature of its convex ventral outline varying from 18 mm. along the lower two-fifths of its length to 30 mm. along the remainder. Its dorsoventral diameter enlarges from 6.8 mm. at 5 mm. from its lower end to 16 mm. at a point 59 mm. farther up. The cross-section of the conch along its entire length is almost circular, but with an almost imperceptible tendency toward angulation along the median part of its ventral side. Along the upper part of the living chamber the shell varies in thickness from almost 1 mm. along its dorsal side to 0.6 mm. ventrally. Along the upper 4 mm. of the length of this chamber the shell thins from the thicknesses indicated to a relatively sharp edge. The margin of the aperture rises ventrally at an angle of about 20 degrees above a plane at right angles to the curving vertical axis of the conch. There is not the slightest trace of a hyponomic sinus. The septum at the base of the living chamber is indicated by a raised transverse line on the inner surface of the shell, a short distance above a completely preserved septum, the latter evidently being the second from the top. Both of these septa curve slightly downward laterally, the amount of this curvature scarcely equalling 1 mm. The sutures of these septa rise in a ventrad direction at an angle of about 15 degrees above a plane at right angles to the curving vertical axis of the conch. The length of the living chamber is about 16 mm. along its ventral side and about 12 mm. dorsally. The height of the uppermost camera is 2 mm., but nothing is known of the height of the immediately underlying ones. The concavity of the septa is small. The siphuncle is about 1.5 mm. in diameter at the top of the phragmacone, and is almost in contact with the ventral wall

of the conch. The surface of the shell appears to have been smooth; at least, no transverse striae are visible at present. Holotype; no. 1296. Plate 25, figs. 1 A, B.

A second specimen from the same locality is 40 mm. long along its ventral outline. The radius of curvature along its convex ventral outline varies from 15 mm. along its lower half to 20 mm. farther up. The septa are preserved both at the top and the bottom of the specimen, that at the top rising ventrally at about the same rate as that at the top of the phragmacone of the type of this species, as seen through the translucent walls of the living chamber. At the top of this specimen the siphuncle is 1.4 mm. in diameter. It is almost in contact with the ventral wall of the conch. Where the diameter of the specimen is 11 mm., about 6 segments of the siphuncle occur in a corresponding length. Their diameter is 1.5 mm. and they evidently are strongly contracted where in contact with the septa beneath, but the size of the septal foramen can not be determined. No. 1298b in the National Museum of Canada, originally associated incorrectly with the type of *Cyrtoceras falx* Billings, here placed under *Richardsonoceras*. Plate 25, figs. 2 A, B.

Occurrence.—Paquette Rapid, at Allumette Island, on the Ottawa River, Canada; in the Leray member of the Black River. In the National Museum of Canada.

Remarks.—In this species the flattening of the ventrolateral sides of the conch is almost imperceptible, there being no suggestion of a median ventral angulate area on ordinary observation.

109. *Loganoceras massasaugaense* Sp. nov.

Plate 25, figs. 4 A, B, C

Specimen closely similar to the type of *Loganoceras regulare* (Billings) in its circular cross-section, its lengthwise curvature, and its rate of enlargement, but differing in the distinct striation of the surface of the shell in a directly transverse manner. At mid-length, these striae number about 7 or 8 in a length of 2 mm. The specimen is about 40 mm. long along its curving vertical axis, with a radius of curvature of 17 mm. along its concave dorsal side. Its ventral outline is still imbedded in the matrix. Its lateral

diameter enlarges from 6 mm. near its base to 12.5 mm. near its top.

Occurrence.—Massasauga Point, Bay of Quinte, near Belleville, Ontario; in the upper part of the Trenton. No. 7228, in the National Museum of Canada.

110. *Loganoceras paquettense* Sp. nov.

Plate 25, figs. 5 A, B, C

Specimens circular in cross-section, strongly curved lengthwise, the radius of curvature of the concave dorsal outline varying from 10 mm. below diameters of 11 mm. to about 15 mm. above this level in the specimens at hand. In one specimen that part of the phragmacone which is preserved enlarges laterally from a diameter of 8 mm. at its base to 14 mm. at its top, the interval being 30 mm., measured along the ventral outline of the conch. The living chamber is at least 13 mm. long laterally. The sutures of the septa rise ventrally at an angle of about 10 degrees with the curving vertical axis of the conch. These septa are only slightly concave in a dorsoventral direction, and even more faintly concave laterally. About 5.5 camerae are indicated by the segments of the siphuncle along the ventral outline of the conch where the diameter of the latter is 11 mm. These segments are about 1.5 mm. in diameter and are almost in contact with the ventral wall of the conch. In a second specimen its dorsoventral diameter is 13 mm. where its lateral one is 14 mm. No trace of transverse striae are visible on the surface of the shell.

Occurrence.—Paquette Rapid, at Allumette Island, in the Ottawa River, Ontario. No. 7229, in the National Museum of Canada.

Remarks.—Compared with typical *Loganoceras regulare* (Billings), the conch of this species curves more strongly lengthwise and enlarges at a more rapid rate.

111. *Loganoceras* (?) cf. *paquettense* Sp. nov.

Plate 29, figs. 2 A, B

Specimen 33 mm. in length along the convex ventral outline of its phragmacone. Above this level the dorsolateral part of the

living chamber is preserved for a length of 13 mm. The radius of curvature of the ventral outline increases from 20 mm. along its lower half to 30 mm. farther up. The cross-section of the conch is circular. Its dorsoventral diameter increases from 11 mm. at its base to 18 mm. at a point 29 mm. farther up. About 9 camerae occupy a length equal to the diameter of the conch when counted along its ventral outline. The sutures of the septa are nearly straight, but rise at an angle of about 15 degrees in a ventrad direction above a directly transverse plane. The siphuncle is located very close to the ventral wall of the conch, and its upper segments appear as though flattened along their area of contact with this wall. These upper segments are at least 1.5 mm. in width, and evidently are strongly contracted at the septal necks.

Occurrence.—St. Joseph Island, in the northwestern part of Lake Huron; in the Black River. No. 14471 in the museum of the University of Michigan.

Remarks.—In its curvature and rate of enlargement this specimen bears considerable resemblance to *Loganoceras paquettense* Foerste, but the surface of the shell is not preserved, and there is a possibility that this specimen may have belonged to some species of *Zitteloceras*.

KENTLANDOCERAS Gen. nov.

Genotype.—*Kentlandoceras schrocki* Foerste.

Conchs differing from typical *Loganoceras* chiefly in their small lengthwise curvature; circular in cross-section, with the siphuncle located close to the ventral wall of the conch; lower part of each segment of the siphuncle almost in contact or in actual contact with the latter. Sutures of septa straight, either directly transverse to the curving vertical axis of the conch or rising moderately in a ventrad direction.

112. *Kentlandoceras schrocki* Sp. nov.

Plate 7, figs. 2 A, B

Holotype 10 mm. long, the living chamber occupying 7 mm. of this length, while the 4 camerae still attached to this chamber occupy a combined length of 3 mm. The convex ventral outline

of the conch has a radius of curvature of about 25 mm. Its lateral diameter enlarges from 4.5 mm. at its base to 5.1 mm. at the base of the living chamber, and to 7 mm. at its aperture. Its cross-section is circular. The sutures of the septa rise slightly in a ventrad direction. The siphuncle is narrowly exposed along the median line of each of the upper 3 camerae. Its diameter here is estimated at 0.5 mm., the exact diameter being unknown.

Occurrence.—Kentland, in northwestern Indiana; in the Black River dolomite. Collected by Robert R. Schrock. No. 87116, U. S. National Museum.

113. **Kentlandoceras wilsonae** Sp. nov.

Plate 25, figs. 6 A, B

Orthoceras drummondi Billings, Pal. Foss. 1, Geol. Surv. Canada, 173 (1865), in part. Not the figured specimen of *Orthoceras drummondi*, but selected here as the type of *Kentlandoceras wilsonae*.

Two fragments, possibly parts of the same conch. The upper fragment includes the living chamber, 7 mm. long, and the seven upper camerae of the phragmacone, its total length being 16 mm. The lower fragment is 11 mm. long and exhibits only the exterior form of the conch. The two fragments have a total length of 27 mm.

The upper fragment has a radius of curvature of 25 mm. along its convex ventral outline. Its lateral diameter enlarges from 6 mm. at its base to 8.25 mm. at a point 9.5 mm. farther up, increasing to 9.5 mm. at the aperture after an additional interval of 9.5 mm. Along the lower half of this fragment the cross-section of the conch is circular, but toward the aperture it is slightly depressed, the dorsoventral diameter here equalling 8.3 mm. The 7 camerae still attached occupy a length equal to the diameter of the conch at the top of the phragmacone. The sutures of the septa are almost directly transverse to the curving vertical axis of the conch. In the original condition of the specimen the septum at its base apparently exposed the siphuncle with a diameter of 1 mm. at its passage through this septum, the siphuncle being almost in contact with the ventral wall of the conch; but, on

slightly filing down the surface of this septum in order to get further knowledge of its structure, no trace of this supposed siphuncle remained. However, there appears to be a trace of the siphuncle along the median part of the ventral side of the four lower camerae still preserved, almost in contact with the ventral wall of the conch.

The lower fragment is 11 mm. long, and attains a diameter of 5.2 mm. at its top. Its cross-section is nearly circular.

Occurrence.—Near Kingston, Ontario, Canada; in the Black River formation; associated with the lectotype of *Orthoceras drummondi* Billings, and numbered 1271 b, d, in the order here described, in the National Museum of Canada. Named in honor of Alice E. Wilson.

Remarks.—The two fragments here described apparently gave rise to that part of the description of *Orthoceras drummondi* Billings which stated that the siphuncle is "small, slightly dilated between the septa, situated close to the margin, but not in contact with the shell."

114. *Kentlandoceras husseyi* Sp. nov.

Plate 29, figs. 1 A, B

Specimen 26 mm. long, slightly curved lengthwise, the radius of curvature of its convex ventral outline equalling about 60 mm. The length of the living chamber is 16 mm. The dorsoventral diameter enlarges from 6.9 mm. at the base of the specimen to 10.2 mm. at the top of the phragmacone and 13.2 mm. at the top of the living chamber. The corresponding lateral diameters are 7.8 mm., 10.8 mm., and 13.8 mm. Nine camerae occupy a total length of 9 mm., being slightly longer at the top of the series. At this rate, 11 camerae should occur in a length equal to the lateral diameter of the conch at the top of the series counted. Two shallow vertical grooves mark the surface of the cast of the interior of the conch. These are 12 mm. apart, one on each side of the median line of the ventral face of the cast. They are about three-fifths of a millimeter in width. The sutures of the septa are almost straight, curving only faintly downward laterally, with their lowest level at the vertical grooves just described. Dorsally these

sutures are nearly directly transverse, but toward the top of the phragmacone they tend to rise slightly in a ventrad direction. It is not known that the vertical grooves occur in all specimens of this species. The siphuncle is assumed to have been located close to the ventral side of the conch.

Occurrence.—Mineral Point, Wisconsin; in the Platteville member of the Black River. No. 14424, in the museum of the University of Michigan.

Remarks.—Compared with *Kentlandoceras wilsonae*, the camerae of this species are relatively more numerous.

LAPHAMOCERAS Gen. nov.

Genotype.—*Cyrtoceras corniculum* Hall, Rep. Geol. Surv. Wisconsin, 41, figs. 1, 2 (1862); later changed to *Cyrtoceras tenuistriatum* by Hall in Miller's Amer. Pal. Foss., 243 (1877); referred to *Zitteloceras* by Foerste, Jour. Sci. Labs. Denison Univ., 23, 198, pl. 43, figs. 4 A, B (1928).

Conchs similar to *Zitteloceras* in general appearance and internal structure, but with more numerous transverse striae, the latter not being wavy or frilled as in the genus named.

In typical *Zitteloceras* the transverse markings are distinctly raised above the general level of the surface of the shell as narrow lamellae, though the height of these lamellae usually is very short. It is the crests of these lamellae which are frilled transversely to their length.

In *Zitteloceras percurvatum* Foerste (Jour. Sci. Labs. Denison Univ., 23, 196, pl. 43, figs. 1 A, B, C (1928)), the transverse striae are closely crowded as in *Laphamoceras tenuistriatum*, but the latter are frilled, as in typical *Zitteloceras*.

The specimen described by Clarke under *Cyrtoceras billingsi* is here provisionally referred to *Laphamoceras*, under the name *Laphamoceras scofieldi*. The transverse striae are equally prominent and numerous as in the genotype, but the presence of a relatively narrow and shallow hyponomic sinus is only poorly indicated, the preservation of the specimen being poor along the median part of its ventral side.

115. *Laphamoceras scofieldi* Sp. nov.

Plate 27, fig. 5

Cyrtoceras billingsi Clarke, Geol. Minnesota, 3, pt. 2, 806, pl. 60, fig. 10 (1897).

Specimen at least 55 mm. in length, measured along its convex ventral outline. Its dorsoventral diameter enlarges from 7 mm. at its base to 15 mm. at a point 28 mm. farther up ventrally. At this rate of enlargement the dorsoventral diameter at the top of the specimen should be 30 mm. and its total length should be somewhere near 75 mm. The radius of curvature of the lower part of its ventral outline is 20 mm., apparently changing to 40 mm. farther up. The radius of curvature of the lower part of its dorsal outline is 10 mm. Originally the cross-section of the conch was circular, but at present its left lateral side is crushed in. No trace of either the septa or of the siphuncle remains. The surface of the shell is ornamented by narrow and sharply crested transverse striae which slope gently downward from the dorsal toward the ventral side of the conch, with a slight accentuation of their downward slope where crossing the median part of its ventral side. The hyponomic sinus evidently was only faintly indicated. Where the diameter of the conch is 12 mm., 11 of these striae occupy a length of 5 mm. along the ventral outline of the conch. Where its diameter is 9 mm., the crushed-in side of the shell shows that these striae originally extended outward as very narrow and thin lamellae, as in *Zitteloceras*. However, there is no trace of distinct undulation of their crests, as in that genus.

Occurrence.—Cannon Falls, Minnesota; in the Platteville member of the Black River. No. 207, in the collection of W. H. Scofield, belonging to the museum of the University of Minnesota, Holotype.

ZITTELOCERAS Hyatt

Genotype.—*Cyrtoceras lamellosum* Hall, Pal. New York, 1, 93, pl. 41, figs. 2 a-c, (1847). *Cyrtoceras hallianus* D'Orbigny, Prodr. Pal., 1, 1 (1849). *Zitteloceras lamellosum* Hyatt, Proc. Boston Soc. Nat. Hist., 22, 284 (1884). *Zitteloceras hallianum* Foerste

Journ. Cincinnati Soc. Nat. Hist., 22, 51, pl. 3, figs. 5 A, B (1917); Journ. Sci. Labs. Denison Univ., 23, 193, pl. 43, figs. 3 A, B (1928).

Conchs distinctly curved lengthwise, often strongly curved. Cross-section nearly circular, or slightly depressed dorsoventrally. Sutures of septa only faintly curved downward laterally, rising in a ventrad direction, the amount of this rise increasing toward the upper end of the phragmacone. Siphuncle near the ventral wall of the conch, possibly in contact with the latter in some species. Surface of shell ornamented by relatively distant transverse raised lamellae, which usually are but slightly elevated above the general level of the surface. These lamellae undulate transversely, this transverse undulation being characteristic of the genus. On the median part of the ventral side of the conch these transverse lamellae or elevated striae curve distinctly downward, forming a relatively narrow V-shaped sinus, locating former positions of the hyponomic sinus.

116. *Zitteloceras hallianum* (D'Orbigny)

Cyrtoceras lamellosum Hall (not Verneuil, 1842), Pal. New York, 1, 93, pl. 41, figs. 2 a-c (1847).

Cyrtoceras hallianus D'Orbigny, Prodr. Pal., 1, 1 (1849).

Zitteloceras hallianum Foerste, Jour. Cincinnati Soc. Nat. Hist., 22, 51, pl. 3, figs. 5 A, B (1917).

Holotype 23 mm. long, 10 mm. of this length belonging to the body cavity. Beneath this 5 camerae occupy a total length of 5.5 mm. At the base of the living chamber the lateral diameter is 11.5 mm. and the dorsoventral one is 9.5 mm. At the base of the specimen the lateral diameter is 9 mm. The living chamber contracts toward the aperture. The surface of the shell is ornamented by relatively distant sharp, undulate, squamose, transverse lamellae, of which 8 occur in a total length of 10 mm. Along the median line of the ventral side of the conch these lamellae curve distinctly downward, indicating the former presence of a narrow hyponomic sinus.

Occurrence.—Middleville, New York; in the Trenton formation. No. 823, Amer. Mus. Nat. Hist.

117. *Zitteloceras billingsi* (Salter)

Plate 27, figs. 1 A, B; 2 A, B; 8

Cyrtoceras billingsi Salter, Geol. Surv. Canada, Canadian Organic Remains, decade 1, 33, pl. 7, fig. 6 (not fig. 5) (1859).

Cyrtoceras billingsi Bassler, Bibliographic Index of American Ordovician and Silurian Fossils, Bull. 92 of U. S. National Museum, 1338 (1915); designating Salter's fig. 6 as the type of his species *Cyrtoceras billingsi* (not his fig. 5).

Specimen 45 mm. long, measured along its ventral outline, strongly curved lengthwise. The radius of curvature of its convex ventral outline varies from 15 mm. along its lower half to 25 mm. farther up. Its lateral diameter enlarges from 6 mm. at its base to 16 mm. at its top. Its cross-section is circular. This is most accurately determined a little above mid-length, where both diameters are 13 mm. long. Where the lateral diameter is 7.8 mm., the immediately underlying camera is 2 mm. long, those farther down becoming rapidly shorter. Near the top of the specimen, where its lateral diameter is 16 mm., 14 transverse narrow ridges occur in a corresponding length, when counted along its ventral outline. At its extreme top two ridges are 3 mm. apart, which is a distinctly greater distance than immediately below, and indicates gerontic conditions. At this diameter of 16 mm. the transverse ridges curve strongly downward along the median part of the ventral side of the conch, indicating here a former V-shaped hyponomic sinus 5 mm. wide and 2.5 mm. deep. There are local traces of undulations along the crests of some of these transverse ridges. Formerly these ridges probably supported narrow lamellar extensions of the shell, as in typical *Zitteloceras*. Holotype; no. 1299a. Plate 27, figs. 1 A, B.

A second specimen, closely similar in form, but only 35 mm. long, is faintly depressed at a lateral diameter of 12 mm. It is of interest chiefly on account of its gerontic condition, the transverse ridges not only becoming more distant but tending to disappear locally along the upper part of the specimen. The siphuncle is exposed at the top of the specimen where the diameter of the latter is estimated at 15 mm. Here the diameter of the siphuncle

is about 1.5 mm. and it is almost in contact with the interior of the ventral side of the shell. Specimen not figured by Billings; no. 1299b. Plate 27, fig. 8.

Occurrence.—Paquette Rapids, in the Ottawa River, at the lower end of Allumette Island, province of Quebec, Canada; in the Leray member of the Black River formation. Specimen no. 1299a is the one represented by 6 on plate 7 of the publication by Salter, cited above. Both specimens here described are in the National Museum of Canada.

A third specimen from the same locality differs only in enlarging at a slightly smaller rate than in the two preceding ones here described. It is numbered 1277c. in the same museum. Plate 27, figs. 2 A, B.

Remarks.—The specimen represented by Salter's figure 5 on his plate 7, cited above, evidently belonged to a species distinct from that of his figure 6 on the same plate. Unfortunately this specimen is lost. The curvature along its lower end is almost geniculate, the radius of curvature of its convex ventral outline here being about 25 mm., changing to 100 mm. along its upper half. Its rate of enlargement also is much less, increasing from 13 mm. at its base to 20 mm. at a point 60 mm. farther up, when measured in a dorsoventral direction. The transverse ridges are relatively more distant from each other and their crests are distinctly wavy. The siphuncle is relatively small. The specimen evidently can no longer be referred to *Zitteloceras billingsi*, since Bassler selected Salter's fig. 6 as the type. That leaves it without a name; but, in the absence of the original specimen, it would be of little service to propose one.

118. *Zitteloceras* (?) *brevicurvatum* (Whitfield)

Plate 27, figs. 3, 4

Oncoceras brevicurvatum Whitfield, Geol. Wisconsin, 4, 234, pl. 7, fig. 2 (1882); *Cyrtoceras brevicurvatum* on plate.

The type of this species has been lost. Judging from the figure published by Whitfield, cited above, its length along its ventral outline was 40 mm. The radius of curvature of this convex outline was 23 mm. Its dorsoventral diameter increased from 8 mm.

at its base to 15 mm. at its top, indicating an apical angle of 10.5 degrees. Six camerae occurred in a length equal to its dorsoventral diameter. According to the accompanying description, its cross-section was nearly circular, with its dorsoventral diameter barely perceptibly smaller than the lateral one. The dorsal side of this cross-section was a little more flattened than its ventral one, the latter being slightly angular. Septa moderately concave, not arching up on its ventral side. Siphuncle small, located just within the ventral wall. Surface smooth.

Occurrence.—Hess quarry, Beloit, Wisconsin; in the upper part of the Buff dolomite, in the Platteville member of the Black River.

Remarks.—This type was characterized chiefly by its strong curvature and its relatively rapid rate of enlargement. The ventral saddles of the sutures of its septa evidently were low, though the slight angularity of the ventral side of its cross-section suggests a corresponding slight upward curvature of the sutures of the septa here. Whether the absence of any traces of surface markings, such as are characteristic of *Zitteloceras*, has any special significance, is not known. Possibly it signified only that the specimen was a cast of the interior of the conch, instead of preserving also some of the characteristic features of its exterior surface.

In the museum of the University of Michigan there is a specimen from Beloit, Wisconsin, which resembles the type figured by Whitfield in its strong lengthwise curvature, rate of enlargement, and the smoothness of the cast of the interior of the conch. The specimen is 57 mm. long, measured along its ventral outline. Its living chamber occupies apparently 27 mm. of this length, but its upper part is poorly preserved. The radius of curvature of its ventral outline enlarges from 20 mm. along its lower half to 30 mm. toward its top. Its dorsoventral diameter increases from 10 mm. to 12.5 mm. in a length of 18 mm., this length being measured along its ventral outline. Farther up its ventral side is partly weathered away, but its lateral diameter increases to 15 mm. at a point 13 mm. farther up, the cross-section of the lower half of the specimen being almost circular. These measurements indicate an apical angle of 9 degrees. About 5.5 camerae occur in a length

equal to the dorsoventral diameter. The sutures of the septa rise only slightly in a ventrad direction along the dorsolateral parts of the conch, but more strongly ventrolaterally, the total rise equaling about 10 degrees. The median part of the ventral side of the cross-section of the conch is faintly angulate, and here there is a corresponding low angulation of sutures of the septa, the dorsal saddles in other respects being relatively inconspicuous. No. 2866, Univ. of Michigan. Plate 27, fig. 4.

A second specimen from the same locality, and in the same museum, is 40 mm. long, measured along its ventral outline. The radius of curvature of this outline is 20 mm. Its dorsoventral diameter enlarges from 8 mm. near its base to 12 mm. at a point 24 mm. farther up, indicating an apical angle of 9.5 degrees. At the uppermost suture of a septum preserved its dorsoventral diameter is 11.4 mm., and the number of camerae in a corresponding length is between 5.5 and 6. The sutures of the septa are nearly straight, and rise in a ventrad direction at an angle of 10 degrees. The specimen is a cast of the interior of the conch, but retains also a few traces of the shell. This shell is thin, and both the surface of the shell and of the cast of its interior are distinctly ribbed transversely. These ribs number about 7 in a length equal to the dorsoventral diameter of the conch. Dorsolaterally they slope only slightly downward in a ventrad direction, but ventrolaterally they curve increasingly downward, indicating a relatively deep hyponomic sinus. On the surface of the shell these ribs are relatively narrow and acute, and their crests, where better preserved, show the characteristic transverse undulations of *Zitteloceras*. If this second specimen belongs to the same species as the first, there is good reason to believe that both might be regarded as topotypes of the species originally described and figured by Whitfield as *Oncoceras* and *Cyrtoceras brevicurvatum*. No. 2466, Univ. of Michigan. Plate 27, fig. 3.

The Beloit specimen described as *Zitteloceras beloitense* Foerste (Jour. Sci. Labs. Denison Univ., 23, 194, pl. 43, figs. 2 A-D (1928)), is less strongly curved lengthwise; it enlarges dorsoventrally at an angle of 7 degrees; and the camerae are relatively a little longer, compared with their dorsoventral diameter. Otherwise it closely

resembles the specimens here identified with *Zitteloceras brevicaameratum*, and may prove specifically identical.

119. *Zitteloceras clarkeanum* Foerste

Plate 27, figs. 6 A-D

Cyrtoceras hallianum Clarke, Geol. Minnesota, 3, pt. 2, 805, pl. 60, figs. 11, 12 (1897).

Zitteloceras clarkeanum Foerste, Journ. Cincinnati Soc. Nat. Hist., 22, p. 52 (1917).

Specimen 60 mm. in length measured along its convex ventral outline. The radius of curvature of this outline varies from 30 mm. along the phragmacone to about 35 mm. along the living chamber. The dorsoventral diameter of the conch increases from 16.6 mm. near the lower end of the specimen to 24 mm. at a point 33 mm. farther up, when measured along its ventral outline, and to 25.5 mm. at the top of the specimen after an additional interval of 25 mm. Originally the cross-section of the conch probably was almost circular, as in other species of this genus. At present, however, it is strongly compressed, its lateral diameter being estimated at 21 mm. where its dorsoventral diameter is 25.5 mm. Of the living chamber a length of 25 mm. is preserved ventrally and 17 mm. dorsally. Where its dorsoventral diameter is 21 mm., 6 camerae occur in a corresponding length when counted along its ventral outline immediately beneath. Along the lower part of the specimen the sutures of the septa rise moderately in a ventrad direction, but on approaching the upper part of the phragmacone these sutures rise at an increasing rate until at the base of the living chamber they form an angle of 10 degrees with a directly transverse plane. The course of these sutures is almost straight, curving only faintly downward along the lateral sides of the conch. The siphuncle is very close to the ventral wall of the conch but is not known to be in actual contact with the latter. The surface of the shell is ornamented by sinuous striae whose crests project slightly in a lamellose manner. About 5 of these striae occur in a length of 5 mm. where the dorsoventral diameter of the specimen is 22 mm., if counted along its ventral outline. The undulations of these transverse striae are conspicuous, about 5 downward

deflections occurring in a width of 10 mm., at the diameter mentioned. The general course of these undulating striae is almost directly transverse to the curving vertical axis of the conch, but along the median part of its ventral side they curve rather abruptly downward for a width of 7 mm. and a depth of fully 2 mm. or slightly more. This indicates the presence of a sharply defined hyponomic sinus at various stages of growth of the conch.

Occurrence.—Janesville, Wisconsin, in the Platteville member of the Black River. Collected by Charles Schuchert, and numbered 4120 in the museum of the University of Minnesota. Holotype.

Remarks.—Compared with typical *Zitteloceras hallianum* D'Orbigny, from the Trenton at Middleville, New York, the conch is much larger, curves more strongly, and enlarges more rapidly.

Compared with *Zitteloceras sinuatum* (Billings), the surface of the shell is not transversely annulated but is ornamented by relatively coarse and strongly undulated transverse lamellae, which rise abruptly, but for a very short distance, above the general surface.

120. *Zitteloceras* (?) *sinuatum* (Billings)

Plate 27, figs. 7 A, B

Cyrtoceras sinuatum Billings, Geol. Surv. Canada, Rept. Progress for 1853-56, 315 (1857).

Specimen 70 mm. in length, measured along its convex ventral outline. The radius of curvature of this outline increases from 25 mm. along the lower 25 mm. of its length to 50 mm. along its upper 35 mm. Its dorsoventral diameter enlarges from 10 mm. at its base to 20.5 at the highest part of the phragmacone along its ventral side, and to 25 mm. at the top of the living chamber, the lower interval being 45 mm. and the upper one 25 mm. in length. Where the dorsoventral diameter of the conch is 17 mm. about 6.5 camerae occupy a corresponding length immediately beneath. At the top of the phragmacone, where its dorsoventral diameter is 20.5 mm., 7 camerae occur in the immediately underlying 14 mm., indicating by their shorter length that the conch was fully mature.

The sutures of the septa are almost directly transverse along the dorsal side of the conch, but on approaching the median part of its ventral side they rise at an increasing rate, forming conspicuous and somewhat angular saddles. The siphuncle is not clearly defined but is assumed to be located near the ventral wall of the conch. The surface of the shell is ornamented by relatively narrow but distinct annulations. Where the dorsoventral diameter of the conch is 22 mm., about 8 of these annulations occur in a corresponding length immediately beneath. Along the phragmacone these annulations are almost directly transverse, except along the median part of its ventral side, where they curve abruptly downward for a length of 3 mm. and a width of 7 mm., indicating former locations of the hyponomic sinus. Along the upper 15 mm. of the length of the living chamber the annulations give way to more closely crowded lines of growth, which rise distinctly from the dorsal toward the ventral side of the conch. It is assumed that the crsts of these annulations formerly continued outward in the form of very narrow lamellae, undulating as in typical *Zitteloceras*. However, there is no distinct evidence of such lamellae, the surface of the shell not being preserved distinctly.

Occurrence.—La Petite Chaudière, at the western margin of the city of Ottawa, Ontario, Canada; in the Black River formation. No. 1302, National Museum of Canada; holotype.

WETHERBYOCERAS Foreste

Genotype.—*Cyrtoceras conoidale* Wetherby, Journ. Cincinnati Soc. Nat. Hist., 4, 78, pl. 2, fig. 6 A (1881).

Conch a breviconic cyrtoceroid, circular in cross-section, with the siphuncle located close to its ventral side. Sutures of septa rising slightly in a ventrad direction along the upper part of the phragmacone. Septa only slightly concave. Siphuncle near, but not in actual contact with the ventral wall of the conch. Its segments are obliquely globular in form, and are strongly contracted at the septal necks. Cross-sections of the siphuncle exposing 10 to 12 vertical lamellae converging from the outer walls of the siphuncle toward its interior, but leaving an open central space.

121. *Wetherbyoceras vallandighami* (Miller)*Plate 31, figs. 5 A, B*

Cyrtoceras vallandighami Miller, Cincinnati Quarterly Journal of Science, 1, 232, fig. 23 (1874).

The specimen figured by Miller was about 26 mm. long along its convex ventral outline, the radius of curvature of this outline being about 24 mm. The dorsoventral diameter of the conch enlarged from about 4.5 mm. at its base to 14 mm. at its top. The cross-section was nearly circular, the dorsoventral diameter being slightly greater, and the ventral side of the section being slightly more narrowly rounded than the dorsal side. Where the dorsoventral diameter is 9 mm., there are 8 camerae in a corresponding length along its ventral side. Where this diameter is 14 mm. there are also 8 camerae. The upper part of the specimen is figured as hollow, only the outer part of the camerae being preserved, next to the inner side of the shell.

The species appears to be rare, *Wetherbyoceras conoidale* being much more common. A distorted specimen of *Wetherbyoceras vallandighami* obtained in the Fairmount member of the Maysville formation at Cincinnati, Ohio, is in the U. S. National Museum, and is there numbered 48330.

This specimen is 18 mm. long along its ventral outline, and has a radius of convex curvature there of 25 mm. Its dorsoventral diameter enlarges from 9 mm. at its base to 14.5 mm. at its top. The sutures of the septa originally were almost straight, but rose slightly in a ventrad direction. About 10 camerae occur in a length equal to the dorsoventral diameter. The siphuncle is 2 mm. in diameter at the top of the specimen, and is 1 mm. from the ventral wall of the conch. Its interior exposes traces of several vertical lamellae converging from the walls of the siphuncle toward its interior, but not reaching the center, its structure being actinosiphonate. The shell is weathered away, only a cast of the interior of the conch remaining. This consists chiefly of a deposit of calcite, less than 1 mm. thick, lining the outer wall of the interior of the camerae, and partially enclosing the siphuncle. The remainder of the interior of the conch is occupied by crystalline

calcite at the top of the specimen, while at its base several of the septa have weathered away, leaving a hollow place, similar to that at the top of the specimen figured by Miller. The concavity of these septa evidently was slight, as shown by one partially preserved within the cavity at the lower end of the specimen.

CYRTORIZOCERAS Hyatt

Genotype.—*Cyrtoceras minneapolis* Clarke, Geol. Minnesota, 3, pt. 2, 808, pl. 59, figs. 1-8 (1897). *Cyrtorizoceras minneapolis* Hyatt, Zittel-Eastman, Text-book of Paleontology, 529 (1900); Foerste, Jour. Sci. Labs. Denison Univ., 21, 316, pl. 35, figs. 3 A-C (1926).

Three specimens were figured by Clarke, and these three are the only specimens available to the writer. The two smaller specimens, evidently regarded by Clarke as typical, enlarge rapidly and are rather strongly curved, their dorsal outlines being distinctly concave. The larger specimen presents a similarly concave dorsal outline, and a similar, though less conspicuous enlargement of the dorsoventral diameter of the living chamber. It is assumed that the reference of the larger specimen to the same species as the two smaller specimens is correct. In that case, *Cyrtorizoceras* differs from typical *Beloitoceras* in the distinctly concave curvature of its dorsal outline, and in the rapid expansion of the conch dorsoventrally, even along the living chamber of mature specimens.

The generic description, essentially as given by Hyatt, but with slight alterations, is as follows:

Cross-sections more compressed laterally than in *Rizoceras*; living chamber shorter and apt to be more or less laterally compressed toward the aperture in gerontic stages of growth; but the dorsoventral diameters shorten here only very slightly or not at all. Sutures more curved downward laterally, and with decided ventral and dorsal saddles.

122. *Cyrtorizoceras minneapolis* (Clarke)

Plate 29, figs. 4 A, B, C, D; 7 A, B; plate 9, fig. 7

Cyrtoceras minneapolis Clarke, Geol. Minnesota, 3, pt. 2, 808, pl. 59, figs. 1-8, (1897).

Cyrtorizoceras minneapolis Hyatt, in Zittel-Eastman, Text-book of Paleontology, 529 (1900); generic reference.

The original of Clarke's figures 1-4, cited above, is a living chamber (Plate 29, figs. 4 A, B), 15 mm. long along its convex ventral outline, the radius of curvature of this outline being 25 mm. Its dorsoventral diameter enlarges from 10.9 mm. at its base to 16.4 mm. at its aperture. The corresponding lateral diameters are 8.4 mm. and 11.2 mm., the lateral walls being virtually parallel along the upper 2 mm. of their length. The dorsal outline is evenly concave. The suture of a septum is located 2 mm. above the base of the ventral side of the specimen, leaving 13.5 mm. for the length of the living chamber along its ventral outline. This suture is virtually straight, but rises slightly in a ventrad direction. The concavity of this septum is 2.5 mm. The margin of the aperture arches slightly upward from its dorsal side as far as the ventrolateral side of the conch and then curves downward at a more rapid rate toward the hyponomic sinus, whose depth is about 1 mm. Along the lower part of the specimen the transverse striae on the surface of the shell curve increasingly downward in a ventrad direction on the ventral half of the shell.

The original of Clarke's figures 5 and 6, cited above, also is a living chamber (Plate 29, figs. 4 C, D), with a dorsoventral diameter of 15.5 mm. and a lateral one of 11.1 mm. at its top. Traces of camerae are exposed at its base, 2 camerae occurring in a length of 3 mm. ventrolaterally, where the dorsoventral diameter of the conch is 9.5 mm. There is a faint tendency toward parallelism between the lateral walls of the living chamber along the upper 1 mm. of its length.

Occurrence.—Minneapolis, Minnesota; in the Platteville member of the Black River. Collected by J. C. Kassube, and presented to the University of Minnesota.

The original of Clarke's figures 7, 8, cited above, is a living chamber with 2 camerae attached, one segment of the siphuncle projecting beneath its base (Plate 29, figs. 7 A, B). The specimen is 25 mm. long, measured along its ventral outlines and 18 mm. long on its dorsal side. It is curved lengthwise, the radius of curvature of its convex ventral outline being 25 mm. along all but the top of

the specimen, changing to 15 mm. here. Along its dorsal outline the radius of concave curvature also is 25 mm. Its dorsoventral diameter enlarges from 15.5 mm. at its base to 17 mm. at the base of the living chamber, increasing to 21 mm. at a point 6 mm. below the ventral side of the aperture, this maximum diameter continuing as far as the aperture. The lateral diameter enlarges from 12 mm. at the base of the specimen to 14.8 mm. at a point nearly 6 mm. below the aperture, and then diminishes to 14 mm. at the aperture. This lateral compression of the upper part of the living chamber is the characteristic feature mentioned by Hyatt in his description of the genus *Cyrtorizoceras*. It is accompanied by a ventrolateral flattening of the upper part of the living chamber, toward its aperture. The outline of this aperture is narrowly oval, its ventral part being distinctly more narrowly rounded than its dorsal part. In contrast with this, the cross-section at the base of the specimen is only slightly more narrowly rounded ventrally than dorsally. The two camerae at the base of the specimen are 5 mm. long ventrally, and only 2.5 mm. dorsally. The sutures of the septa are almost straight. The concavity of the septum at its base is 2.2 mm. The siphuncle here is 2.5 mm. in diameter and its segments are inverted oval in outline, their narrower ends facing downward. Their lower halves are in contact with the ventral wall of the conch, their upper halves being free, as in many other cyrtoceroids. The surface of the living chamber is transversely striated, and also is almost imperceptibly annulated along its upper half. These transverse striae and annulations arch upward laterally, but curve much more strongly downward ventrally than dorsally, indicating a moderately deep but narrow hyponomic sinus, tending to be angular along the median part of this sinus. From the same locality and horizon as the preceding specimens. No. 46525, U. S. National Museum.

MAELONOCERAS Hyatt

Genotype.—*Phragmoceras praematurum* Billings, Canadian Naturalist and Geologist, 5, 173, fig. 19 (not fig. 20), (1860).
Maelonoceras praematurum Hyatt, Proc. Boston Soc. Nat. Hist., 22, 280 (1884). *Maelonoceras billingsi* Foerste, Jour. Sci.

Labs. Denison Univ., 20, 244, pl. 39, figs. 5 A, B, C (1924) (not figs. 6 A, B, C).

In his original description of *Maelonoceras*, Hyatt not only selected Billings's species *Phragmoceras praematurum* as the genotype but designated his figure 19 as the type. This was equivalent to selecting the original of his figure 19 as the type of Billings's species. Foerste, therefore, was in error when he selected the original of Billings's figure 20 as the type, and described the original of his figure 19 as *Maelonoceras billingsi*. It, therefore, becomes necessary to drop the name *Maelonoceras billingsi* and to restore the name *Maelonoceras praematurum* (Billings) for the original of Billings's figure 19. This leaves the original of Billings's figure 20 without a name, and, therefore, the designation *Beloitoceras clochense* here is proposed (page 107). With these changes in mind, the following description of the genus *Maelonoceras* results.

Only the living chamber is known at present. This is erect, with straight and parallel dorsal and ventral outlines, the lateral outlines converging slightly toward the aperture. Cross-section distinctly compressed laterally, the ventral side more narrowly rounded. Aperture pyriform, with its ventrolateral parts curved inward, resulting in a nearly circular outline along the dorsal lobe, narrowing into a broad hyponomic sinus with subparallel lateral sides, rounded ventrally.

RICHARDSONOCERAS Gen. Nov.

Genotype.—*Cyrtoceras simplex* Billings, Geol. Surv. Canada, Rept. of Progress for 1853–56, 313 (1857).

Conchs similar to *Beloitoceras*, but enlarging less rapidly in a dorsoventral direction, and hence more elongate. The dorsal outline of the living chamber tends to be more concave, in continuation of the concave outline of the phragmacone. The siphuncle tends to be a little larger, but the more elongate form of the conch and its more distinctly concave dorsal outline are the chief characteristics of this genus. Including *Richardsonoceras simplex* (Billings), *Richardsonoceras beloitense* Foerste, *Richardsonoceras romingeri* Foerste, and *Richardsonoceras scofieldi* (Clarke). The

species described by Billings as *Cyrtoceras falx* may belong here. Possibly the species identified by Clarke with *Cyrtoceras neleus* Hall, and here described as *Richardsonoceras clarkei*, belongs to this genus, but only its phragmacone is known.

123. *Richardsonoceras simplex* (Billings)

Plate 26, figs. 1 A, B; 2; 3; 4; 5 A, B

Cyrtoceras simplex Billings, Geol. Surv. Canada, Rep. Progress for 1853-56, 313 (1857).

Specimen 118 mm. long when measured along its ventral diameter. Strongly curved lengthwise, the radius of curvature of its convex ventral outline varying from 30 mm. along the lower 40 mm. of its length to 40 mm. for the remainder of its length. Its dorso-ventral diameter increases from 12 mm. at its base to 24 mm. at mid-height of the living chamber and then the cast of the interior of the conch diminishes slightly toward the aperture. For a length of 8 mm. beneath the aperture this cast of the interior is distinctly contracted ventrally but this contraction becomes faint along the median part of the lateral sides and may disappear dorsally. This contraction evidently indicates a thickening of the interior of the shell just beneath the aperture. The lateral diameter of the conch increases from 10 mm. at its base to 19.5 mm. at mid-height of the living chamber, and then apparently decreases slightly toward the aperture, aside from the contraction of the cast of its interior mentioned above. Its cross-section is more narrowly rounded ventrally than dorsally. The living chamber is about 22 mm. in height when measured along the median part of its lateral sides. Where the dorsoventral diameter of the conch is 23 mm. seven camerae occur in a corresponding length when counted along their ventral outline, and similar ratios occur along the lower part of the specimen. The sutures of the septa curve downward laterally about 3 mm. Their ventral saddles rise about 5 mm. above their level dorsally, most of this rise being ventrad of the median part of the lateral sides. The siphuncle is close to the ventral side of the conch, but its exact dimensions can not be determined. The cast of the interior of the living chamber apparently is slightly flattened ventrolaterally at the

aperture, and the median part of its ventral side here is more narrowly rounded, as in typical specimens of *Beloitoceras*; but the dorsal outline of its living chamber is slightly concave, rather than convex, differing in that respect from typical representatives of that genus. Plate 26, figs. 1 A, B.

Occurrence.—Lot N, concession A, Nepean township, Carleton county, Ontario, Canada; in the Black River. Holotype; no. 1303, in the National Museum of Canada.

Additional specimens occur in lot 4, concession 3, Gloucester township, Carleton county. One of these, about 100 mm. in length along its ventral outline, retains the shell which is three-fourths of a millimeter thick along the living chamber. The surface of the shell is almost smooth for the greater part of its length, but at two levels it retains transverse striae which are directly transverse dorsally but curve increasingly downward from the dorsoventral parts of the conch in a ventrad direction, indicating the former presence of a distinct hyponomic sinus. In another specimen 65 mm. long and 19 mm. in diameter dorsoventrally at the base of the living chamber, the immediately underlying segments of the siphuncle are 3 mm. long, 3.75 mm. wide, and narrow abruptly at the septal necks so as to leave a foramen only 1 mm. in diameter. The length of these necks is very short and the details of their structure can not be determined under an ordinary lens. In a third specimen, nearly 70 mm. long ventrally, the siphuncle is about half a millimeter from the ventral wall of the conch where its dorsoventral diameter is 20 mm. The segments of the siphuncle here are 3 mm. in diameter at midlength, narrowing to about 2 mm. where in contact with the segments, the septal foramen probably being 1 mm. in diameter, as in the preceding specimen. No. 7393, A, B, National Museum of Canada. Plate 26, figs. 3, 4.

A closely similar specimen was found on St. Joseph's Island, in the Black River, probably along the northeastern coast of this island. The length of this specimen is nearly 125 mm., and it enlarges in this length from a dorsoventral diameter of 5 mm. near its base to 25 mm. at its top. Its living chamber is 23 mm. long. The segments of the siphuncle along the upper end of the

phragmacone are almost or actually in contact with the ventral wall of the conch and are 3.5 mm. in diameter, narrowing abruptly where in contact with the septa, as in the specimens from Carleton county, in eastern Ontario. No. 13352, museum of Univ. of Michigan. Plate 26, fig. 2

124. *Richardsonoceras* (?) *falx* (Billings)

Plate 26, fig. 6; plate 7, figs. 1 A, B, C

Cyrtoceras falx Billings, Geol. Surv. Canada, Rep. Progress for 1853-56, 314 (1857); Salter, Geol. Surv. Canada, decade I, 32, pl. 7, figs. 1, 4 (not figs. 3, 3 a) (1859).

Specimen consisting of the phragmacone, 79 mm. long when measured along its ventral outline. Strongly curved lengthwise; the radius of curvature of its convex ventral outline varying from 15 mm. along its lower 19 mm., to 20 mm. along the following 23 mm., and to about 32 mm. along the remainder of its length. Its dorsoventral diameter enlarges from 5 mm. at its base to 20 mm. at its top. The corresponding lateral diameters are 4.25 mm. and 15.6 mm. The sutures of the septa curve moderately downward laterally, their ventral saddles rising about 5 mm. above the level of their dorsal saddles at the top of the specimen. In a dorsoventral direction the concavity of the septum is estimated at 4 mm. Only the septum at the top of the specimen is preserved. Here the passage of the siphuncle through the septum and the distance of the latter from the ventral wall of the conch are both estimated at about 1.5 mm. Surface of shell weakly striated transversely, the hyponomic sinus evidently shallow. Holotype; no. 1298. Plate 26, fig. 6; plate 7, fig. 1 A.

A second specimen 52 mm. in length along its ventral outline enlarges dorsoventrally from 2.2 mm. near its base to 14.1 mm. at its top. Along the lower 21 mm. of its length it exposes the sutures of the septa distinctly, and for an additional distance of 5 mm. rather obscurely, along the ventral half of the conch. Where its dorsoventral diameter is 8.5 mm. about 7 camerae occur in a corresponding length along its ventral outline. Specimen no. 1298a. Plate 7, fig. 1 B.

A third specimen 40 mm. long with a dorsoventral diameter of 12 mm. at its top, here exposes the siphuncle, 1 mm. in diameter and 1 mm. from the ventral wall of the conch. Specimen no. 1298c. Plate 7, fig. 1 C.

Occurrence.—Paquette Rapids, at the lower end of Allumette Island, on the Ottawa River, Quebec, Canada; in the Leray member of the Black River formation. Three specimens numbered 1298, 1298a, and 1298c, in the Victoria Memorial Museum. Of these the one numbered 1298 is selected as the holotype, and is the one represented by Salter's figure 1, on his plate 7, cited above.

Remarks.—The siphuncle of this species is not known well enough to determine whether it conforms with that of typical *Richardsonoceras* in relative size. However, the lateral compression of the conch and its rate of curvature lengthwise are similar.

125. *Richardsonoceras beloitense* Sp. nov.

Plate 37, figs. 3 A-D

Cyrtoceras camurum Whitfield, Geol. Wisconsin, 4, 231, pl. 7, figs. 7, 8, 9 (1882); also Clarke, Geol. Minnesota, 3, pt. 2, 805, pl. 60, figs. 5, 6 (1897).

The specimen figured by Whitfield has been lost. The two fragments figured by Clarke from another quarry in the same general area and horizon belong to two individuals, the lower and shorter fragment of his figures including the extreme top of a phragmacone, while the upper fragment includes both the upper 7 camerae of the phragmacone and also the living chamber, as will be noted in the following description.

Specimen about 50 mm. long, slightly curved lengthwise, the radius of curvature of its convex ventral outline equalling 70 mm. The living chamber is 29 mm. long. The margin of its aperture curves evenly and gradually downward from the middle of its lateral sides as far as its ventral part, differing in this respect strongly from Whitfield's figures. At the base of the living chamber its dorsoventral diameter is 29 mm. and its lateral one, in the present condition of the specimen, is 19.5 mm. At present, its cross-section is sublenticular, with its longer axis in a dorsoventral direction, but originally this cross-section probably was more ovoid,

and strongly compressed laterally, but with the ventral part of its transverse outline distinctly more narrowly rounded than its dorsal part. The ventrolateral parts of the conch tend to be flattened. The number of camerae in a length equal to the dorsoventral diameter is estimated at 8 along the ventral outline of the conch. The sutures of its septa curve downward laterally about 2 mm. at the top of the phragmacone. The siphuncle is almost in contact with the ventral wall of the conch. Only one segment of the siphuncle is exposed, at the bottom of the specimen, and that is similar to those exhibited by the smaller specimen from the same locality. The septum at the base of the specimen is strongly curved dorsoventrally, but is of only slight depth in a lateral direction. The phragmacone enlarges dorsoventrally from a diameter of 26.5 mm. at its base to 29 mm. at the base of the living chamber and appears to retain this larger diameter as far as the aperture.

The smaller fragment figured by Clarke is 22 mm. long along its ventral outline and retains here 6 segments of the siphuncle, all of approximately the same size and length. Along its dorsal outline these 6 camerae occupy a total length of 13 mm., above which there are 2 additional camerae with a total length of slightly less than 2 mm. These two upper camerae, much shorter than the underlying ones, indicate that the conch had reached full maturity. There is even a trace of the basal part of the living chamber. The siphuncle is almost in contact with the ventral wall of the conch. The segments at the base of the specimen are 4 mm. long, and 4 mm. wide at their upper margin, narrowing to 3.5 mm. at their contact with the underlying septa, the septal foramen at its base apparently being 2.5 mm. in width, though it may have been smaller. Viewed from a lateral direction the structure of the siphuncle appears scalariform, the dorsal outline of each segment rising at an angle of 20 to 25 degrees with the ventral outline of the conch, and its basal part inserted almost 1 mm. ventrad of the top of the dorsal outline of the next underlying segment. The septum at the base of the specimen has a concave curvature with a radius of 15 mm. both dorsoventrally and laterally, but its lateral diameter is so much shorter that the curvature in this direction is not readily noticed as being at an equal rate.

Occurrence.—Samp's quarry, near Beloit, Wisconsin; in the Black River. No. 4115, in the museum of the University of Minnesota.

Remarks.—This species belongs to a group in which the lengthwise curvature of the conch is much less than in typical *Richardsonoceras*, as typified by *Richardsonoceras simplex* (Billings). In other respects it appears closely similar.

126. *Richardsonoceras romingeri* Sp. nov.

Plate 26, fig. 7

Specimen differing from *Richardsonoceras beloitense* in its smaller size; the maximum downward curvature of the sutures of the septa is distinctly dorsad of the center of the conch, and the rise of these sutures toward the ventral side of the conch is relatively straighter and a little higher. Length of specimen 39 mm., of which length 24 mm. is occupied by the living chamber, and the remainder by 6 camerae. Its dorsoventral diameter enlarges from 19.3 mm. at its base to 21 mm. at the base of the living chamber and to approximately 22.5 mm. at the aperture. In a lateral direction the corresponding diameters are 13 mm., 13 mm., and 15 mm. The ventral part of its cross-section is distinctly more narrowly rounded than its dorsal part. The outline of the aperture is almost directly transverse from the dorsal side of the conch as far as its ventrolateral parts, and then curves distinctly downward, resulting in a hyponomic sinus about 2 mm. deep compared with its ventro-lateral margin. At the top of the phragmacone, where its dorsoventral diameter is 21 mm., 6 camerae occupy a length of 17 mm. along their ventral outline, or at the rate of slightly more than 7 in a length equal to this diameter. The siphuncle is located close to the ventral wall of the conch, and its structure is assumed to be similar to that of *Richardsonoceras beloitense*.

Occurrence.—St. Josephs Island, Lake Huron, Ontario; in the Black River. No. 2460 in the museum of the University of Michigan.

127. *Richardsonoceras* (?) *clarkei* Sp. nov.*Plate 37, figs. 5 A, B*

Cyrtoceras neleus Clarke, Geol. Minnesota, 3, pt. 2, 804, pl. 59, fig. 20 (1897).

Specimen 65 mm. long, measured along its ventral outline, possibly including the extreme basal part of the living chamber. The lower third of its concave dorsal outline has a radius of curvature of 30 mm., changing to 40 mm. farther up. Its dorsoventral diameter enlarges from 9.5 mm. near the base of the specimen to 17 mm. at a point 50 mm. farther up along its ventral outline, the corresponding lateral diameters being 8.5 mm. and 15.5 mm. Where this dorsoventral diameter is 17 mm. almost 8 camerae occur in a corresponding length. The sutures of the septa rise from the dorsal toward the ventral side of the conch at an increasing rate, the ventral saddles rising about 3 mm. above the level of the same sutures dorsally. The siphuncle is near the ventral wall of the conch, and is 1.8 mm. in diameter where the dorsoventral diameter of the conch is 16.2 mm. On lateral view, the dorsal outline of the siphuncle presents a series of offsets at each septum resulting in a scalariform structure. No trace of the surface of the shell is preserved.

Occurrence.—Beloit, Wisconsin; in the Platteville member of the Black River. No. 4136, in the museum of the University of Minnesota.

Remarks.—Compared with typical members of the genus *Richardsonoceras* the conch is not as strongly compressed laterally, and does not enlarge as rapidly in a dorsoventral direction.

128. *Richardsonoceras* (?) *scofieldi* (Clarke)*Plate 26, figs. 8 A, B*

Cyrtoceras scofieldi Clarke, Geol. Minnesota, 3, pt. 2, 810, pl. 59, figs. 9-11 (1897).

Specimen closely resembling *Richardsonoceras romingeri* in the curvature of the sutures of its septa, but smaller, and less compressed laterally, the median part of the ventral side of its cross-section being only faintly angular. Specimen 30 mm. long, that

part of the living chamber which is preserved being 11 mm. long. Its dorsoventral diameter enlarges from 12 mm. at the base of the specimen to 15.1 mm. at the base of the living chamber and to 15.6 mm. at 5 mm. farther up. The lateral diameter enlarges from 10.1 mm. at its base to 13 mm. at the base of the living chamber, and to 13.5 mm. 5 mm. farther up, above which it decreases to 13 mm. at the top of the specimen which is 6 mm. farther. Where the dorsoventral diameter of the specimen is 15.5 mm., slightly over 7 camerae occupy a corresponding length when counted along their ventral outline. The crests of the ventral saddles of the sutures of the septa are subangular along their median parts. The siphuncle is located close to the ventral wall of the conch and is assumed to be similar to that of *Richardsonoceras beloitense* in structure.

Occurrence.—Janesville, Wisconsin; in the Platteville member of the Black River. No. 4121 in the museum of the University of Minnesota.

Remarks.—That part of the living chamber of this specimen which is preserved bears some resemblance to the corresponding part of *Beloitoceras*, but the rate of enlargement of the conch dorsoventrally is much less, and hence this specimen is assigned provisionally to *Richardsonoceras*. Nothing is known at present of the size and relative structure of the segments of its siphuncle.

BELOITOCERAS Foerste

Genotype.—*Oncoceras pandion* Hall, Rept. Supt. Geol. Surv. Wisconsin, for 1861, 45; *ibid*, for 1862, 41, fig. 3; Whitfield, Mem. Amer. Mus. Nat. Hist., 1, pt. 2, 69, pl. 9, figs. 21, 22, (1895). *Beloitoceras pandion* Foerste, Jour. Sci. Labs. Denison Univ., 20, 245, pl. 36, figs. 5 A, B; pl. 41, figs. 4 A, B, C (1924).

Conch relatively short, strongly compressed laterally, with the ventral side more narrowly rounded; moderately enlarging laterally. Margins of aperture arching moderately upward laterally or ventrolaterally, but curving downward rather strongly at the hyponomic sinus. Upper part of aperture often constricted by a thickening of the inner wall of the shell near the top of the living chamber. Sutures of septa curving slightly downward laterally,

but rising at an increasing angle in a ventrad direction on approaching the upper end of the phragmacone. Siphuncle of medium size, compared with related cyrtoceroids, and almost in contact with the ventral wall of the conch, especially along the lower half of the camerae.

Compared with typical *Oncoceras*, the conch enlarges much less laterally at the top of the phragmacone and the base of the living chamber, and the dorsal gibbosity is much less conspicuous. There is a faint tendency toward gibbosity along the lower half or two thirds of the living chamber, but in most cases this part of the dorsal outline merely tends to be straight, becoming slightly or more distinctly concave farther up.

129. *Beloitoceras janesvillense* Sp. nov.

Plate 30, figs. 1 A, B, C, D, E; 4

Oncoceras pandion Clarke, Geol. Minnesota, 3, pt. 2, 802, pl. 58, figs. 5, 6 (1897).

Specimen 52 mm. long on its ventral outline, the living chamber being preserved laterally for a length of 22 mm. The radius of curvature of its convex ventral outline equals 30 mm., except along the upper part of the living chamber where it is somewhat greater. Its dorsoventral diameter enlarges from 14 mm. at its base to 24 mm. at the base of the living chamber, and then retains the latter diameter for a distance of 10 mm. above the ventral side of the suture of the septum at the base of this chamber, contracting to 22 mm. at the aperture. At 12 mm. above the suture just mentioned, ventrolaterally, and at 10 mm. above dorsally there is a faint and broad contraction of the cast of the interior of the living chamber. The lateral diameter of the specimen increases from 11 mm. at its base to 19 mm. at the top of the phragmacone, and then decreases to about 15.5 mm. at the aperture. The cross-section of the conch is oval, with the median part of its ventral side more narrowly rounded, especially along its living chamber, whose ventrolateral sides tend to be distinctly flattened. The upper two camerae are successively shorter than the immediately lower camerae of the phragmacone. Where the dorsoventral diameter is 23.5 mm., 7 camerae occupy a corresponding length along

their ventral outline. The lateral downward curvature of the sutures of the septa at the top of the phragmacone scarcely equals 1 mm. but they rise distinctly in a ventrad direction. The cast of the interior of the phragmacone is faintly and broadly ribbed in a vertical direction, their number equalling about 6 in a width of 10 mm. at the top of the phragmacone. Plate 30, figs. 1 A-E.

Occurrence.—Janesville, Wisconsin; in the Platteville member of the Black River. Holotype, no. 8300 in the museum of the University of Minnesota.

Remarks.—This specimen differs from typical *Beloitoceras pandion*, from the same horizon at Beloit, Wisconsin, in its more rapid rate of enlargement dorsoventrally, and in its greater lateral compression. The convexity of its ventral outline is closely similar. The original of Clarke's figures 5 and 6 cited above.

Chatfield specimen.—The specimen illustrated by figure 4 published by Clarke on the plate cited above is labelled as coming from Chatfield, Minnesota. It is similar to the type of *Oncoceras janessvillense* in the rate of enlargement of its phragmacone and in the curvature of the ventral outline of the latter. However, the cross-section of the conch is much less compressed laterally and the median part of its ventral side is less angular in cross-section. At the base of the living chamber its dorsoventral diameter is 24 mm. and its lateral one is estimated at 21 mm. The ventral outline of this chamber is not preserved except at its base. In the present condition of the specimen this chamber appears to contract strongly toward the aperture, but this may be due in large part to the weathering away of the upper part of its ventral side. If the Chatfield specimen represents a distinct species it will require a better preserved specimen to demonstrate that fact. No. 8303, in the Museum of the University of Minnesota. Plate 30, fig. 4.

130. *Beloitoceras huronense* (Billings)

Plate 30, figs. 3 A, B, C

Cyrtoceras huronense Billings, Geol. Surv. Canada, Pal. Foss., 1, 176, text figures 158a, b (1865).

Specimen 30 mm. long. The radius of curvature of its convex ventral outline is 25 mm.; the concavity of its dorsal outline has a depth of 1 mm., chiefly owing to the outward curvature of the upper two-thirds of the living chamber. Its dorsoventral diameter enlarges from 11 mm. at its base to 15.7 mm. on a level with the dorsal side of the base of the living chamber, and above this it contracts to about 13.8 mm. at the aperture. The corresponding lateral diameters are 10 mm., 12.25 mm., and 8 mm. The dorsal and ventral transverse curvatures of the conch are closely similar, there being a very faint tendency toward flattening of the ventrolateral sides of the phragmacone, and a slightly narrower rounding of its ventral side. The lower 7 camerae occupy a length of 15.5 mm., when counted along the ventral outline of the conch, this being also the dorsoventral diameter at the top of the series counted. The three overlying camerae are conspicuously shorter dorsally, but only moderately shorter ventrally. The result is that the suture of the septum at the base of the living chamber rises conspicuously toward the ventral side of the conch, while that at the top of the fifth camera from the base of the specimen is almost at right angles to its dorsal outline, and below this level the sutures slope increasingly downward in a ventrad direction. The siphuncle is 1.5 mm. in diameter and almost in contact with the ventral wall of the conch. Its segments enlarge slightly within the camerae. The maximum lateral diameter of the conch is located at the point where the conspicuous shortening of the camerae at the top of the phragmacone begins. Above this point the conch contracts rapidly, especially in a lateral direction. Possibly a part of this lateral contraction is due to compression after the death of the animal. However, in its present condition the aperture of the living chamber resembles a narrow ellipse, with its major axis in a dorsoventral direction, and with the ventral end of this ellipse not perceptibly more narrowly rounded than its dorsal end. Plate 24, fig. 3 B.

Occurrence.—St. Joseph Island, in the northwestern part of Lake Huron; Ontario, Canada; in the Black River formation. Holotype; specimen no. 1297c, in the National Museum of Canada.

Remarks.—This species is characterized chiefly by its small size; its dorsal margin along the top of the phragmacone and the lower half of the living chamber is almost straight, and only faintly concave.

131. *Beloitoceras houghtoni* (Clarke)

Plate 30, figs. 9; 10 A, B; plate 28, fig. 7

Cyrtoceras houghtoni Clarke, Geol. Minnesota, 3, pt. 2, 807, pl. 59, figs. 12–15 (1897).

The original of figures 13 to 15, published by Clarke and cited above, here is selected as the type of the species. The original of his figure 12 has been cut vertically in a dorsoventral direction, and in its present condition is of little value, except as indicating the course of the transverse striae.

Specimen (Plate 30, fig. 9) nearly 40 mm. long, measured along its ventral outline, only 32 mm. of this outline being well preserved. Of the living chamber a length of 14 mm. is preserved at one point, its original length being estimated at 18 mm., judging from the relative length of the living chamber of the specimen illustrated by Clarke's figure 12. The radius of curvature of its convex ventral side is about 32 mm. Its dorsoventral diameter enlarges from 9 mm. at the base of the specimen to 16 mm. at the base of the living chamber and to 16.8 mm. at a point 8 mm. farther up. In its present condition, its lateral diameter is 11 mm. where its dorsoventral one is 16.8 mm.; however, a third specimen from the same locality, unfigured (Plate 30, figs. 10 A, B), has a lateral diameter of 13 mm. where its dorsoventral one is 17 mm., and the latter appears more normal, while the former, here described, probably was compressed laterally after the death of the animal. About 8 camerae occupy a length equal to the dorsoventral diameter at the top of the phragmacone. The sutures of the septa curve only slightly downward laterally but rise in a ventrad direction at an angle of about 15 degrees with a directly transverse plane along the upper part of the phragmacone. The septum at the base of the specimen is moderately concave laterally.

The original of Clarke's figure 12 was 46 mm. long and 18.8 mm.

wide at the top of the uppermost well preserved suture of a septum, but apparently there are traces of 2 additional faint sutures with the upper one 3 mm. above the uppermost well preserved one just mentioned, and here the dorsoventral diameter is 19.5 mm. The two faint sutures are indicated in the figure published by Clarke. The lower part of the living chamber is crossed by several low and inconspicuous transverse striae which are almost directly transverse dorsolaterally, but curve distinctly downward ventrolaterally for a distance of at least 2 mm. The height of the living chamber is 20 mm. Plate 28, fig. 7.

The third specimen in this series, but not figured, shows a similar size, curvature, and rate of increase of growth, but its lateral diameter is greater, as already stated, and its camerae are slightly taller, 7 occurring in a length equal to the dorsoventral diameter. Plate 24, figs. 10 A, B.

Occurrence.—Cannon Falls, Goodhue county, Minnesota; in the Platteville member of the Black River. No. 4135, in the Scofield collection in the museum of the University of Minnesota.

Remarks.—Evidently closely related to *Beloitoceras huronense* (Billings), but attaining a slightly larger size. If the specimen represented by Clarke's figure 12 were used as the type, then this species would be characterized by the small downward curvature of sutures of the septa laterally, and their almost directly transverse course along the upper part of the phragmacone. However, in the second specimen, represented by his figures 13 to 15, these sutures rise conspicuously in a ventrad direction, and the camerae are somewhat shorter. A third specimen, not figured by Clarke, but belonging to his type series, has taller camerae, and closely resembles the type of *Beloitoceras huronense*. The second specimen here is selected as the type, since it is the one most adequately figured by Clarke.

132. *Beloitoceras norwoodi* (Clarke)

Plate 30, fig. 6

Cyrtoceras norwoodi Clarke, Geol. Minnesota, 3, pt. 2, 809, pl. 60, figs. 7-9 (1897).

Specimen 31 mm. long, including at its top the living chamber, 19 mm. in length. To this chamber are attached 6 camerae, of approximately equal length, totalling 10 mm. ventrally. Its dorsoventral diameter decreases from 26 mm. at the base of the living chamber to 23.2 mm. at the aperture. The corresponding lateral diameters are 21 mm. and approximately 17 mm. At a level of 8 mm. above the base of the living chamber the conch contracts a little, especially dorsally and dorsolaterally. The margin of the aperture rises a little from its dorsal side to its ventrolateral parts, and then curves downward about 4 mm. at the distinct hyponomic sinus. The sutures of the septa rise slightly from their dorsal side as far as the middle of their lateral course, and then at an increasing rate as far as the middle of their ventral side. The 6 camerae that occupy a length of 10 mm. ventrally, occupy only 8 mm. dorsally, suggesting that more complete specimens would show distinctly curved ventral outlines, as in other species of *Beloitoceras*. The concavity of the septa in a lateral direction apparently does not exceed 2 mm. The siphuncle is located close to the ventral side of the conch, and its segments probably are closely similar to those of the genus named. The surface of the cast of the interior of the phragmacone and of the immediately adjacent part of the living chamber is vertically ribbed, the ribs being low, and numbering about 5 in a width of 10 mm. dorso-laterally and laterally. Farther ventrad they become indistinct. Where the sutures of the septa cross these vertical ribs they curve slightly upward.

Occurrence.—Rockton, Illinois; from the Platteville member of the Black River. No. 4113, in the museum of the University of Minnesota.

Remarks.—This species, as far as known, is characterized by the relative erectness of the upper part of its phragmacone and of its living chamber. The dorsal outline of this upper part of the conch is relatively straight. The sutures of the septa rise moderately in a ventrad direction. The cast of the interior of the conch is vertically ribbed, and the sutures of the septa are correspondingly sinuate. The camerae are relatively short and numerous.

133. *Beloitoceras carveri* (Clarke)*Plate 30, figs. 8 A, B; 7 A, B*

Oncoceras carveri Clarke, Geol. Minnesota, 3, pt. 2, 801, pl. 58, figs. 7-9 (1897).

Oncoceras lycus Clarke, *ibid.* 799, pl. 58, figs. 1-3.

Specimen 31.5 mm. long, consisting of a living chamber 20 mm. long laterally, and of 4 camerae, of which the uppermost one is conspicuously shorter than the remainder. The radius of curvature of its convex ventral outline is 27 mm. Its dorsal outline has a corresponding concavity. The specimen enlarges from 21 mm. at the base of the third camera beneath the living chamber to 22.8 mm. at a point 5 mm. above the suture at the base of this chamber and then diminishes to 19 mm. at the aperture. The corresponding lateral diameters are 14 mm., 15 mm., and 12.3 mm. In descending order, the length of the camerae is 1.5 mm., 3.2 mm., and 3.0 mm. The sutures of the septa curve only faintly downward laterally, and rise slightly in a ventrad direction. The concavity of the septa equals 2.5 mm., and the passage of the siphuncle through the septum is almost 2 mm. in diameter. Its distance from the ventral wall of the conch is 2 mm. The margin of the aperture rises in a ventrad direction along its dorsolateral parts and then curves downward increasingly along its ventrolateral part for a distance of 5 mm., resulting in a hyponomic sinus about 2 mm. deep. About 8 mm. beneath this margin the conch is slightly constricted by a shallow transverse groove, about 3 mm. wide, and parallel to the aperture rather than to the suture at the base of the living chamber. The upper part of this chamber retains faint traces of transverse striae, parallel to the margin of the aperture. Holotype, no. 2193, in the museum of the University of Minnesota. Plate 30, figs. 8 A, B.

A second specimen, figured by Clarke under the name *Oncoceras lycus*, apparently is identical in every essential, except that its lateral diameter is relatively greater. It consists of the living chamber and 4 well preserved camerae, of which the uppermost is distinctly shorter. At the base of the living chamber, where its dorsoventral diameter is 21 mm., the lateral one is 18 mm. There

is a trace of a transverse groove 7 or 8 mm. below the margin of the aperture. The septum at its base has a concavity of almost 4 mm. The passage of the siphuncle here is almost 2 mm. in lateral direction and apparently is less than half a millimeter from the ventral wall of the conch. No. 8302, in the museum of the University of Minnesota. Plate 28, figs. 7 A, B.

Occurrence.—Minneapolis, Minnesota; in the Platteville member of the Black River.

Remarks.—The type of the species *Oncoceras carveri* appears to belong to the same species as that described by Clarke under the name *Oncoceras lycus*, but apparently was compressed laterally after the death of the animal.

Compared with typical *Oncoceras lycus* the cross-section of the conch is less flattened dorsally, and more elongated in a dorso-ventral direction. The species is more comparable with *Oncoceras plebeium* (Hall) in size and cross-section, but it does not show the slightly gibbous convexity along the lower two-thirds of the dorsal outline of its living chamber.

134. **Beloitoceras isodorus** (Billings)

Plate 30, figs. 2 A, B

Cyrtoceras Isodorus Billings, Geol. Surv. Canada, Pal. Foss., 1, 175, figs. 157a, b (1865).

Specimen 43 mm. long, the radius of curvature of its convex ventral outline being 30 mm., and that of its concave dorsal outline being about the same, but the two outlines diverge, the dorso-ventral diameter of the conch increasing from 13 mm. at the base of the specimen to 21.5 mm. at the base of the living chamber on its ventral side, above which it retains this diameter for at least half the height of the living chamber, possibly decreasing slightly toward the aperture. The lateral diameter varies from 10.8 mm. at the base of the specimen to 15.5 mm. at the base of the living chamber, and then gradually diminishes to about 13.2 mm. at the aperture. The uppermost camera is distinctly shorter than those beneath. The number of camerae in a length equal to the dorso-ventral diameter of the conch is almost 8. The cross-section of the conch is oval, with a tendency toward flattening ventrolat-

erally, its ventral side being distinctly more narrowly rounded than its dorsal one. The sutures of the septa curve slightly downward laterally, the depth of this curvature not exceeding half a millimeter. At the base of the specimen they rise only slightly in a ventrad direction, but at the top of the phragmacone their ventral saddles rise almost 5 mm. above their dorsal parts. The siphuncle is almost in contact with the ventral wall of the conch and at the top of the phragmacone its segments are almost 2.5 mm. in diameter. These segments widen moderately within the camerae. The outline of the aperture is somewhat ovoid, its lateral parts converging in a ventrad direction. Traces of the surface of the shell at the top of the living chamber retain transverse raised lines or striae which curve distinctly downward, about 2 mm. beneath their course laterally, on approaching the ventral side of the chamber, thus indicating the presence of a distinct hyponomic sinus.

Occurrence.—St. Joseph Island, in the northwestern part of Lake Huron, Ontario, Canada; in the Black River formation. Holotype, no. 1304, in the National Museum of Canada.

Remarks.—This species is characterized by the relatively strong rise of the sutures of its septa in a ventrad direction.

135. *Beloitoceras clochense* Sp. nov.

Plate 37, fig. 4

Phragmoceras praematurum Billings, Canadian Naturalist, 5, fig. 20 (1860) (not fig. 19, which is the lectotype of *Maelonoceras praematurum*; Hyatt, Proc. Boston Soc. Nat. Hist., 22, 280 (1884). *Maelonoceras praematurum* Foerste (not Hyatt), Jour. Sci. Labs. Denison Univ. 20, 242, pl. 39, figs. 6 A, B, C; pl. 41, fig. 7 (1924).

Conch strongly curved lengthwise, strongly compressed laterally, attaining its largest dimensions 5 mm. above the base of the living chamber. Here its dorsoventral diameter is 18.5 mm., and its lateral one is 16 mm. The radius of curvature of the convex ventral outline is 25 mm. The living chamber contracts considerably toward the aperture, its dorsoventral diameter there being 14 mm. and its lateral one 12 mm. The aperture is nar-

rowed by two low but distinct ventrolateral crests, which rise above the level of the dorsal outline of the aperture and converge slightly toward each other. In the vicinity of these crests the lateral walls of the living chamber are somewhat flattened. The dorsal outline of the living chamber is distinctly concave. The sutures of the septa curve faintly downward laterally, and rise toward the ventral side of the conch. The siphuncle is about one-third of a millimeter from the ventral wall of the conch, its segments are slightly fusiform, and enlarge from a diameter of 0.7 mm. where passing through the septa to 0.9 mm. within the camerae. The shell is relatively thick, equalling nearly 1 mm. along the dorsal and dorsolateral parts of the upper half of the living chamber, and nowhere thinning to less than half a millimeter. Interior of shell thickened near the aperture.

Occurrence.—LoCloche Island, in northern Lake Huron; in the Black River. Holotype, no. 1294, National Museum of Canada.

136. *Beloitoceras murrayi* Sp. nov.

Plate 30, figs. 5 A, B

Specimen about 41.5 mm. long, strongly curved lengthwise. The radius of curvature of its convex ventral outline is 25 mm.; that of its concave dorsal outline is 10 mm. along the phragmacone, then the dorsal outline is almost straight for a length of 11 mm. along the greater part of the living chamber, but at its top this dorsal outline curves distinctly outward. The dorsoventral diameter of the conch increases from 16 mm. at the base of the specimen to 21 mm. at the base of the ventral side of the uppermost camera, and then contracts to about 19 mm. at the aperture. The lateral diameter of the conch increases from 15 mm. at the base of the specimen to 20 mm. about 3 mm. above the base of the living chamber laterally, and then contracts to about 16.5 mm. at the aperture, both of the diameters at the aperture being estimated. From the preceding measurements it is evident that the cross-section of the conch is only faintly compressed laterally along the phragmacone and basal part of the living chamber, but is more distinctly compressed toward the aperture. At the aperture there are faint traces of the shell, which suggest that the ventro-

lateral sides of the conch here were slightly flattened, converging in a ventrad direction, and producing an ovoid form of aperture. It is assumed that there was a hypnomic sinus, but this is not certain. There are 3 camerae in a length of 12 mm. along the ventral outline of the conch. Apparently about 6 camerae occurred along a length equal to the dorsoventral diameter at the top of the phragmacone. The sutures of the septa curve downward laterally for a distance of about 1.5 mm. Their ventral saddles rise about 4 mm. above their level dorsally. The siphuncle is close to the ventral wall of the conch. The cast of the interior of the living chamber is contracted for a length of about 10 mm. immediately beneath the aperture. This corresponds to a thickening of the upper part of the shell owing to an annular deposit of calcareous material on its inner surface.

Occurrence.—St. Joseph Island, in the northwestern part of Lake Huron, Ontario, Canada; in the Black River formation. Specimen no. 1297a, National Museum of Canada.

Remarks.—This specimen is characterized by the strong lengthwise curvature of the conch, its dorsal outline being deeply concave, with only a moderate flattening of this outline along the top of the phragmacone and the lower two-thirds of the living chamber. Its lateral diameter is relatively large, compared with its dorsoventral one.

ONCOCERAS Hall

Genotype.—*Oncoceras constrictum* Hall, Pal. New York, 1, 197, pl. 41, figs. 6 a-f, 7 a-d, (1847); Foerste, Jour. Sci. Labs. Denison Univ., 20, 240, pl. 39, figs. 2 A, B, 3, 4 (1924).

Conch short, rapidly enlarging, strongly curved lengthwise, with its maximum dimensions at the top of the phragmacone and the base of the living chamber, contracting thence toward the aperture. Although the general outline of its dorsal side is concave, there is a gibbosity at the top of the phragmacone and base of the living chamber which is more or less distinct along the dorsal side of the conch and usually also affects its lateral outline, producing a more or less distinct inflation of the entire circumference of the conch here. The aperture is oval in outline, more nar-

rowly rounded ventrally, and the hyponomic sinus is distinct but relatively shallow. The siphuncle is close to the ventral wall of the conch and its segments are narrowly fusiform.

137. *Oncoceras collinsi* Sp. nov.

Plate 31, figs. 1 A, B; 2 A, B

Specimen 48 mm. long on its ventral outline, relatively erect and moderately curved. Of this length 24 mm. belongs to the living chamber. The radius of curvature of its ventral outline is 50 mm. along the phragmacone and the lower third of the living chamber, changing to 30 mm. along the upper part of this chamber. Its dorsal outline is only slightly concave, the amount of this concavity equalling about half a millimeter at a point 3 or 4 camerae below the base of the living chamber. Between the base of the second camera below the living chamber and a point 15 mm. above the base of this chamber the dorsal outline is slightly gibbous, the apparent gibbosity of its dorsal outline being accentuated by a transverse groove which characterizes the cast of the interior of this chamber at a level of 15 mm. above its base. This groove is 3 mm. wide, and 1 mm. deep, and is more strongly accentuated along its lower margin than along its upper one, and is deeper dorsally, becoming shallower ventrally. It rises in a ventrad direction at an angle of about 10 degrees with the plane of the suture at the base of the chamber. This groove apparently corresponds to the attachment ring on the inner surface of the shell forming the wall of the living chamber a short distance below the aperture in many orthoconic conchs. The dorsoventral diameter of the conch enlarges from 15 mm. at its base to 24 mm. at a point 7 mm. above the base of the living chamber, and then contracts to 21.5 mm. at the transverse groove on the cast of the interior of this chamber. The corresponding lateral diameters are 15 mm., 23.5 mm., and 20 mm. The cross-section of the conch is more broadly rounded dorsally, and slightly more narrowly rounded along the median part of its ventral side than elsewhere. Eight camerae occupy a length equal to the dorsoventral diameter of the conch. The sutures of the septa are almost directly transverse to the curving ventral outline of the conch, but tend to be

slightly angulate along the median part of the ventral side of the conch, especially toward the top of the phragmacone. The concavity of the septum at a diameter of 16.5 mm. is about 2 mm. Plate 31, figs. 1 A, B.

Occurrence.—Lot 4, concession 3 R. F., Gloucester township, Carleton county, southeast of Ottawa, Ontario, Canada; in the Black River. No. 7230, in the National Museum of Canada.

Remarks.—This species is similar to *Oncoceras douglassi* Clarke in its erectness and general proportions, but differs greatly in its more numerous camerae in a length equal to the diameter of the conch.

A closely similar specimen from Tetreauville, west of Hull and northwest of Ottawa, retains the transverse striae on the surface of the shell. These striae are low, broad, and relatively inconspicuous. About 8 or 9 occur in a length of 5 mm. They are directly transverse dorsally and dorsolaterally, but curve increasingly downward ventrolaterally, indicating a hyponomic sinus whose sides converge at an angle of 140 degrees with each other. No. 6847, in the National Museum of Canada. Plate 31, figs. 2 A, B.

138. *Oncoceras tetreauvillense* Sp. nov.

Plate 31, figs. 7 A, B

Specimen 40 mm. long, 23 mm. of this length belonging to the living chamber. As far as can be judged from the part preserved, the conch was relatively erect, similar in that respect to *Oncoceras collinsi*, but larger and more compressed laterally. The ventral outline has a radius of convex curvature of 50 mm. along the phragmacone and the lower half of the living chamber, a broad, shallow groove or constriction intervening between this and the margin of the aperture. Its dorsal outline is only slightly convex along the entire length preserved. Its dorsoventral diameter enlarges from 23 mm. at its base to 29 mm. at 6 or 7 mm. above the base of the living chamber, narrowing to less than 26 mm. at the shallow groove 11 or 12 mm. farther up. The corresponding lateral diameters are 20.5 mm., 26 mm., and 20 mm. The shallow groove on the upper part of the cast of the interior of the living

chamber is occupied by a strong thickening of the shell. This increases in thickness from half a millimeter over the phragmacone and the lower half of the living chamber to at least 1 mm. along the dorsal side of the groove, and to 2 mm. on its ventrolateral parts. The exterior of the shell, on the contrary, contracts quite evenly toward the aperture, the shallow groove evidently being due merely to a thickening of the interior of the shell along the upper half of the living chamber. Eight camerae occupy a length equal to the dorsoventral diameter at the top of the phragmacone. The sutures of the septa are almost directly transverse to the curving vertical axis of the conch. The surface of the cast of the interior of the conch is marked by low and broad ribs, about 6 in a width of 10 mm. at the bottom, decreasing to about 5 at the top of the phragmacone. The surface of the shell is striated transversely by low and relatively inconspicuous lines, that rise slightly in a ventrad direction, compared with the sutures of the septa at base of the living chamber. The margin of the aperture rises in a ventrad direction from its dorsal to its ventrolateral part, curving downward about 2 mm. at the hyponomic sinus.

Occurrence.—Tetreauville, west of Hull, Quebec, northwest of Ottawa; in the Black River. No. 7394, in the National Museum of Canada.

139. *Oncoceras douglassi* Clarke

Plate 31, figs. 3 A, B

Oncoceras douglassi Clarke, Geol. Minnesota, 3, pt. 2, 801, pl. 60, figs. 13-15 (1897).

Specimen 60 mm. long, 20 mm. of this length belonging to the living chamber. The radius of curvature of the convex ventral outline is 60 mm. along the phragmacone and the lower half of the living chamber, above which this outline curves more rapidly as far as the lower margin of the hyponomic sinus. The dorsal outline is slightly concave both along the lower part of the phragmacone and at mid-height of the living chamber, but is distinctly gibbous along the upper part of the phragmacone and the lower half of the living chamber, the amount of this gibbosity equalling about 1.5 mm. The dorsoventral diameter enlarges from 13 mm.

at its base to 27.3 mm. at the base of the living chamber, and then decreases to 24.5 mm. at the distinctly constricted part of this chamber, 10 mm. above its base. The lateral diameter increases from 14 mm. near its base to 24 mm. at the base of the living chamber which is 25 mm. farther up, and then decreases to 18.6 mm. at the aperture. The cross-section is oval, with a tendency toward flattening along the median part of its dorsal side, and also ventrolaterally, the median part of its ventral side being distinctly more narrowly rounded than any other part of the cross-section. About 10 mm. below the living chamber is the top of a series of 4 camerae of which the upper two occupy a total length of 8 mm., and the lower two of 6 mm. along the dorsal outline of the conch, from which it is estimated that possibly 2 camerae occupied the intervening part, directly beneath this chamber, according to which about 7 camerae should occur in a length equal to the dorsoventral diameter of the conch. The sutures of the septa apparently rise at an angle of about 5 degrees with the horizontal in a ventrad direction along the upper part of the phragmacone. The transverse striae on the surface of the shell slope slightly downward laterally, but at an increasing rate ventrolaterally, indicating a moderately deep hyponomic sinus at former stages of growth. The striae are relatively low and inconspicuous, the general aspect of the surface of the shell being almost smooth.

Occurrence.—Hader, Goodhue County, Minnesota; in the Prosser member of the Trenton. No. 243, in the museum of the University of Minnesota.

Remarks.—This species is characterized by the erectness of its conch and the relatively small number of its camerae in a length equal to the dorsoventral diameter of the conch.

140. *Oncoceras casei* Sp. nov.

Plate 31, figs. 4 A, B, C

Specimen 39 mm. long on its ventral outline; small, distinctly curved, and relatively slender. The radius of curvature of its ventral outline is 30 mm. along the phragmacone and the lower half of the living chamber, curving more strongly inward along

the upper half of this chamber. The dorsal outline is distinctly concave along the lower part of the phragmacone and at mid-length of the living chamber, but is virtually straight for a length of 10 mm. along the upper part of this phragmacone and the lower half of the chamber. The dorsoventral diameter enlarges from 8 mm. at its lower end to 13.5 mm. at the base of the living chamber, and then decreases to 11.8 mm. at the aperture. The corresponding lateral diameters are 7 mm., 13.5 mm., and 9 mm. It is the very conspicuous lateral gibbosity of the conch along the upper part of the phragmacone and the lower half of the living chamber which suggests its relationship with typical *Oncoceras*. The specimen does not expose the sutures of its septa. The surface of the shell is almost smooth, but under a lens shows low transverse striae which are almost directly transverse along the dorsal half of the conch, but curve moderately downward in a ventrad direction on its ventral half, indicating the former presence of a relatively shallow hyponomic sinus. At the aperture this sinus is about 1 mm. in depth. The cross-section of the conch is slightly more narrowly rounded along the median part of its ventral side, and scarcely flattened dorsally.

The surface of the shell is distinctly marked by short, narrow transverse, dark brown lines on a general light brown field. These lines are from one-fifth to one-fourth of a millimeter in width vertically, and from 0.5 to 1 mm. in length horizontally. They lie at irregular intervals along the crests of the low transverse striae already described, these crests numbering about 9 in a length of 5 mm. along the dorsolateral parts of the conch. The dark lines, instead of being continuous along the crests of these striae, are broken up at irregular intervals into short sections. They occur around the entire circumference of the conch, but are best preserved dorsally. Here they tend to be arranged into several V-shaped series, with their angles directed downward along the median part of this dorsal side, while laterally there are several indications of zigzag arrangement, the best preserved apices being directed upward. In this respect they resemble the angulate zigzags of *Cyrtoceras decurio* Barrande, rather than the upward arching chevrons of *Cyrtoceras vittatum* and *Cyrtoceras chrysalis*,

also described by Barrande. Unfortunately it will require better preserved specimens to make the exact arrangement of these horizontal color lines definitely known. In the meantime it is interesting to note the relative frequency of zigzag color markings on the surface of shells of small cyrtoceroids.

Occurrence.—St. Joseph Island, in northwestern part of Lake Huron; in the Black River. No. 2458 in the museum of the University of Michigan.

Remarks.—The conch is characterized by its slender proportions, distinctly gibbous laterally, but not dorsally.

WESTONOCERAS Foerste

Genotype.—*Cyrtoceras manitobense* Whiteaves, Trans. Royal Soc. Canada, 7, sec. 4, 80, pl. 13, figs. 3, 4, 5; pl. 15, fig. 4, (1890); *Westonoceras manitobense* Foerste, Journ. Sci. Labs. Denison Univ., 20, 253, (1924); 24, 220, pl. 38, figs. 2, 3 (1929); Contrib. Mus. Pal. Univ. Michigan, 3, no. 3, 49, pl. 5, fig. 1; pl. 11, fig. 5, (1928); Foerste and Teichert, Journ. Sci. Labs. Denison Univ., 25, p. 280, (1930).

Conch laterally compressed, moderately curved lengthwise, its greatest convexity along its ventral outline being about 4 or 5 camerae below the base of the living chamber. Dorsally its outline is almost straight or there is a slight gibbosity two or three camerae beneath the base of the living chamber, with a slight concavity along the lower part of the phragmacone and along most of the living chamber. This living chamber contracts distinctly toward the aperture. The sutures of the septa slant downward in a ventrad direction along the greater part of their length and then rise on approaching the ventral outline, especially along the upper part of the phragmacone. The cross-section of the conch is narrower ventrally than dorsally, and here the sutures tend to form more or less angulate saddles. The siphuncle is near, but not in contact with the ventral wall of the conch. Its segments are barrel-shaped, their upper and lower ends in contact with the adjoining septa.

Whether the Minnesota and Michigan specimens here referred to *Westonoceras minnesotense* belong to that genus can not be

determined at present. Their internal structure appears to be identical. However, the sutures of their septa have a different course and there is no evidence of humping along the upper part of the ventral outline of the phragmacone, as in typical species of *Westonoceras*. In *Westonoceras minnesotense* the sutures of the septa curve downward laterally, but rise somewhat higher ventrally than dorsally, but without any strong upward turn ventrally as in typical *Westonoceras*. In this respect they resemble the genus *Thuleoceras* of Troedsson.

141. *Westonoceras minnesotense* (Clarke)

Plate 33, fig. 1

Oncoceras minnesotense Clarke, Geol. Minnesota, 3, pt. 2, 798, pl. 58, figs. 16-18b (1897).

Westonoceras minnesotense Foerste, Jour. Sci. Labs. Denison Univ., 24, 312, pl. 48, fig. 3 (1929).

Holotype.—Phragmacone slightly curved lengthwise, its ventral outline being slightly convex and its dorsal outline concave; enlarging dorsoventrally at an angle of 14 degrees. The sutures of the lower septa are almost straight but slope downward in a ventrad direction at an angle of 5 degrees with the horizontal. At mid-length the sutures curve downward about 1.5 mm., and the ventral saddles rise to about the same level as the dorsal ones. At the top of the specimen the downward lateral curvature of the septa equals 4 mm., and the ventral saddles rise 3 or 4 mm. above the dorsal ones. The cross-section of the conch is oval, with its ventral part more narrowly rounded. In consequence, the ventral saddles appear somewhat angular, while the dorsal saddles appear less elevated and are more broadly rounded. The concavity of the septum at a dorsoventral diameter of 19 mm. is 1.5 mm. The center of the siphuncle here is 4 mm. from the ventral wall of the conch. The cast of the interior of the conch is vertically ribbed, the number of these ribs within the circumference of the conch being estimated at 46, but they are distinct only laterally, and are difficult to detect ventrally and dorsally.

Occurrence.—Lime City, Minnesota; listed on page cxxi of the Geology of Minnesota, cited above, as from the Fusispira and

Nematopora beds, which form the upper part of the Prosser, but there is a possibility that it came from the overlying Stewartville horizon. Holotype, no. 258A, in the Museum of the University of Minnesota.

142. *Westonoceras* cf. *minnesotense* (Clarke)

Plate 33, figs. 5 A, B

Specimen 58 mm. long along its ventral outline, apparently slightly concave along its dorsal outline and slightly convex along its ventral one, but the specimen is somewhat distorted by pressure after the death of the animal. It enlarges dorsoventrally from a diameter of 16.5 mm. at its base to 42 mm. at a point 46 mm. farther up, its angle of enlargement in this direction being 18 degrees. The downward curvature of the sutures of the septa laterally is relatively small, the siphuncle is located near the convexly curved outline of the conch, and the number of vertical ribs on the surface of the cast of the conch is about 46.

Occurrence.—Cornell, 13 miles northwest of Escanaba, Michigan. No. 14483, in the museum of the University of Michigan.

Remarks.—Aside from its greater angle of enlargement, this specimen bears considerable resemblance to *Westonoceras minnesotense*.

143. *Westonoceras* (?) *ortoni* (Meek)

Plate 33, figs. 3 A, B

Orthoceras Ortoni Meek, Pal. Ohio, 1, 155, pl. 13, fig. 8, (1873).

Specimen 35 mm. long, crushed flat in a lateral direction, the dorsoventral diameter, in its present condition, enlarging from 11 mm. at its base to 25 mm. at a point 29 mm. farther up. The amount of distortion is least at the base of the specimen, and here the cross-section of the conch appears to have been oval, with the ventral side more narrowly rounded. The dorsal and ventral outlines of the conch are virtually straight. The number of camerae in a length equal to the dorsoventral diameter of the conch is 8. The sutures of the septa apparently curved downward laterally and formed a low ventral saddle and a distinctly higher dorsal one, the sutures curving outward on approaching the dor-

sal outline. The shell is not preserved. The cast of the interior of the conch is vertically ribbed, the ribs being low, but distinct, 8 ribs occurring in a width of 10 mm. at a point 20 mm. above the base of the specimen. The septum at the base of the specimen is only slightly concave. The center of the siphuncle is located 2.5 mm. from the ventral wall of the conch where the dorsoventral diameter of the latter is 11 mm. The maximum diameter of the siphuncle here is 2.5 mm., so that it is about 1.25 mm. distant from the ventral wall. The form of the lowest segment of the siphuncle is barrel-shaped, and strongly contracted at the septal necks.

Occurrence.—Crawfish run, near Cincinnati, Ohio; about 200 feet above low water in the Ohio River, in the Southgate member of the Eden formation. No. 48349, in the U. S. National Museum.

Remarks.—The barrel-shaped segment of the siphuncle suggests relationship with *Westonoceras*, but exact determination of its generic relationship requires a better preserved specimen.

RIZOCERAS Hyatt

Genotype.—*Orthoceras indocile* Barrande, *Système Silurien du Centre de la Bohême*, 2, pt. 3, p. 57, pl. 185, (1874); Hyatt, *Proc. Boston Soc. Nat. Hist.*, 22, 276, (1884).

Conch breviconic, slightly compressed laterally, and nearly straight, except at its apical end, where it is slightly curved, with its ventral outline convex. Sutures of septa directly transverse. Siphuncle located near the ventral wall of the conch, small, with elongated segments. Surface of shell transversely striated, the striae curving downward more narrowly along the median part of the ventral side, at former locations of the hyponomic sinus, but also curving downward more widely and for a greater distance dorsally.

144. *Rizoceras* (?) *carletonense* Sp. nov.

Plate 34, fig. 4

Specimen 30 mm. long on its ventral outline, consisting of a living chamber 25 mm. in length, beneath which is exposed a single septum and the upper half of a segment of the siphuncle.

Its ventral outline is slightly convex, while its dorsal outline is nearly straight. Its dorsoventral diameter enlarges from approximately 29 mm. at its base to 38 mm. at its top, the corresponding lateral diameters being 28 mm. and 37 mm. The concavity of the septum at the base of the living chamber is relatively small. The center of the siphuncle is located about 3 mm. from the ventral wall of the conch. Its uppermost segment enlarges from 3 mm. at the septal neck to 5 mm. at midheight within the camera. The form of this segment was moderately taller than wide. The surface of the shell is ornamented with numerous fine raised lines, about 9 or 10 in a length of 2 mm. These appear to slant downward from the dorsal toward the ventral side of the conch, their downward slope increasing slightly along the median part of the ventral side, where the hyponomic sinus is about 10 mm. wide and 1.5 mm. deep.

Occurrence.—Lot 4, concession 3, R.F., in Gloucester township, Carleton county; southeast of Ottawa, Ontario, Canada; in the Black River formation. Holotype, no. 7390, National Museum of Canada.

Remarks.—Compared with typical *Rizoceras*, the margin of the aperture slopes downward chiefly in a ventrad, rather than dorsad direction, and the siphuncle is relatively larger. However, the fragment preserved does not preserve sufficient diagnostic differences to serve as a genotype.

PLECTOCERAS Hyatt

Genotype.—*Nautilus jason* Billings, Canadian Nat. Geol., 4, 464, (1859). *Plectoceras jason* Hyatt, Proc. Boston Soc. Nat. Hist., 22, 269 (1884); Whiteaves, Pal. Foss., 3, pt. 4, Geol. Surv. Canada, 301, pl. 36, figs. 1, 2, (1906).

Conchs enlarging fairly rapidly, at least during their earlier stages of growth. Umbilical perforation large. In the genotype the apical end is not in contact with the dorsal wall of the following volution, at least in the specimen figured by Whiteaves. The ventral side tends to be depressed convex or more or less distinctly flattened. The lateral sides are more strongly convex, and the dorsal side tends to become flattened where in contact with the

preceding volution, though convex where free from contact, especially at gerontic stages of growth. Siphuncle near the ventral side of the conch, distant from the latter a distance about equal to its own diameter. Segments curved lengthwise, cylindrical in form, not enlarging within the camerae. Surface of the shell strongly costated, the costae curving downward in a ventrad direction laterally, forming V-shaped elevations where crossing the median part of the ventral side, the bottom of these V's being distinctly rounded. Parallel to these costae are transverse raised lines or coarse striae. These costae and striae outline former stages of the aperture with its hyponomic sinus. The costae usually are most conspicuous ventrolaterally, and tend to become less conspicuous and even obsolete along the median part of the dorsal side of the conch.

145. *Plectoceras robertsoni* (Hall)

Plate 36, figs. 2 A-D; 3 A, B

Lituities robertsoni Hall, Rept. Superintendent of Geol. Surv. Wisconsin, 38, (1861); Whitfield, Mem. Amer. Mus. Nat. Hist., 1, pt. 2, 64, pl. 10, figs. 4-6, (1895).

Eurystomiles robertsoni Miller, North Amer. Geol. Pal., 2nd Appendix, p. 773, (1897).

Lectotype.—Specimen with a maximum diameter of 60 mm. across its umbilical area, the diameter at right angles to the latter being 48 mm. The specimen consists almost entirely of the phragmacone, though there is a possibility that the uppermost 12 mm. of the length of the conch belongs to the base of the living chamber. In a dorsoventral direction the diameter enlarges, at intervals of half a volution, from 7 mm. at the smaller end of the specimen to 10 mm., 16 mm., and 23 mm., the latter being the diameter at its larger end, the intervening lengths being 42 mm., 65 mm., and 95 mm., when measured along the convex ventral outline of the conch. This indicates an angle of enlargement of the conch in a dorsoventral direction of 4.5 degrees. At the second, third, and fourth points mentioned above, the corresponding lateral diameters are 16 mm., 20 mm., and 28 mm., as near as these diameters can be determined. The conch evidently is strongly

depressed dorsoventrally. Where its lateral diameter is 21 mm., its ventral side is flattened distinctly for a width of 12 mm., and its dorsal side is slightly impressed for a narrower width. The lateral sides of the cross-section are more strongly, but evenly convex. The number of camerae in a length equal to the lateral diameter of the conch equals 5.5 along the smaller end of the specimen, as far as preserved, and increases to 6 or a little more at its larger end. The sutures of the septa are almost directly transverse, with a faint downward curvature laterally. Where the lateral diameter of the conch is 20 mm., the siphuncle has a diameter of 1.75 mm., its segments enlarging but faintly within the camerae. This siphuncle is almost in contact with the ventral wall of the conch, its distance from the latter being about one-fourth of a millimeter. The shell is relatively thick, the ribs on its surface leaving no trace of the interior of the conch. These ribs curve strongly downward ventrolaterally and indicate a broad and deep hyponomic sinus ventrally. The ribs are most distinct ventrolaterally but disappear ventrally, being replaced along the median part of the flattened zone of the ventral side by low, coarse striae. The apical end of the conch, with its smaller volutions, is not preserved. Plate 36, fig. 2 A.

A smaller specimen, with a maximum diameter of 43 mm. across its umbilical area, exposes only one volution. The number of camerae within a length equal to the lateral diameter of the conch equals 5.5 or 6. The sutures of the septa and the transverse ribs are as in the preceding specimen, excepting that these ribs leave their impress on the cast of the interior of the phragmacone ventrolaterally. Plate 36, fig. 2 B.

A third specimen, 35 mm. long, has a lateral diameter of 25 mm. and a dorsoventral one of 21.5 mm. The ventral flattened area is 12 mm. wide. The dorsal impressed zone is 9 mm. wide and about half a millimeter deep. The sutures of the septa curve slightly over 1 mm. downward laterally. Faint impressions of the lateral ribs on the surface of the shell are retained by the cast of the interior of the conch. Plate 36, fig. 2 C.

A fourth specimen consists of a considerable part of a living chamber with part of a single camera at its base. Of this chamber

a length of 78 mm. remains, measured along its convex ventral outline. The lateral diameter enlarges from 28 mm. at its base to 29.5 mm. at its top. The corresponding dorsoventral diameters are 25 mm. and 28 mm. The flattened ventral zone is nearly 14 mm. wide. The dorsal impressed zone is 11 mm. wide at the base of the chamber, becoming more narrow and shallow farther up. Faint traces of the transverse ribbing, indicating the form of the hyponomic sinus, are visible on the cast of the interior of the conch. The suture of the septum at the base of this chamber curves downward laterally, with its ventral margin lower than its dorsal one. The concavity of this septum equals 6 mm. beneath the lower part of this suture laterally. The siphuncle is 3.5 mm. in diameter and slightly more than half a millimeter from the ventral wall of the conch. Plate 36, fig. 2 D.

Occurrence.—Beloit, Wisconsin, and Rockford, Illinois; from the Platteville member of the Black River formation. The two coiled specimens here described are from Rockford, and are numbered 1003-2, American Museum of Natural History. The small fragment of the phragmacone and the living chamber are from Beloit, Wisconsin, and are numbered 1003-1.

Remarks.—The genotype of *Eurystomites* is *Nautilus kelloggi* Whitfield, a laterally compressed conch of Canadian age, with a distinctly impressed dorsal zone. From this genotype the species here described as *Plectoceras robertsoni* differs strongly in its dorsoventrally depressed cross-section. The genotype of *Plectoceras*, originally described as *Nautilus jason* Billings, has a more nearly circular cross-section, with more or less broadly rounded ventral and dorsal sides. In the Black River species *Plectoceras halli* (Foord), *Plectoceras occidentale* (Hall), and *Plectoceras undatum* (Conrad) there is a tendency toward flattening of the ventral side of the conch, but these species have a very shallow dorsal impressed zone, this contact zone in some specimens being merely flattened, instead of impressed.

Michigan University specimens.—Among the fragments of *Plectoceras* in the museum of the University of Michigan is one that resembles *Plectoceras robertsoni* in cross-section and general appearance. It includes a length of 68 mm. belonging to the upper

end of the phragmacone and 10 mm. belonging to the basal part of the living chamber. The radius of curvature of its lower half is 30 mm. Along mid-length the conch appears depressed by pressure after the death of the animal. Its lateral diameter at the top of the phragmacone is estimated at 25 mm. There is a shallow impressed zone, about 5 mm. wide, along the entire length of the dorsal side of the conch. The number of camerae in a length equal to the dorsoventral diameter is estimated at 5. Six transverse ribs occur in a length of 43 mm. when counted along the ventrolateral shoulder of the conch. These ribs curve downward a total distance of nearly 20 mm. from the dorsolateral to the median part of the ventral sides of the specimen. The ribs are prominent only ventrolaterally, becoming nearly obsolete along the median part of the ventral side, and also dorsolaterally. No. 14466. Plate 36, fig. 3 B.

A second specimen in the same collection is 66 mm. in diameter across the umbilical depression. Nearly 70 mm. of the length of the conch belongs to the living chamber, the original length of the latter being unknown. The dorsoventral diameter of the conch at the base of this chamber equals 18 mm. It differs from the preceding specimen chiefly in two respects: 6 transverse ribs occur in a length of 31 mm. along the ventrolateral shoulders, and 4 camerae occur in a length of 20 mm. at the top of the phragmacone, the transverse ribs being more numerous and the camerae less numerous in a length equal to the dorsoventral diameter of the conch. No. 3685. Plate 36, fig. 3 A.

The last two specimens are from Beloit, Wisconsin; from the Platteville member of the Black River formation.

146. *Plectoceras carletonense* Sp. nov.

Plate 36, fig. 1

Specimen including two and a half volutions, apparently preserved as far as the aperture. The living chamber is 95 mm. long and is in contact with the preceding volution apparently as far as the aperture, its dorsal side being slightly impressed within 20 mm. of this aperture. At 50 mm. back from the aperture the dorsoven-

tral diameter of the conch is 25 mm., its lateral diameter being 26 mm. At 116 mm. farther back the corresponding diameters are 15 mm. and 18.5 mm. Below this point two camerae are exposed, presenting a combined length of 5 or 6 mm. ventrally. The sutures of the septa curve slightly downward laterally and appear to be directly transverse ventrally. The concavity of the exposed septum is 2 mm. The siphuncle is almost 3 mm. in diameter and is located almost in contact with the ventral wall of the conch. At the top of the phragmacone, where the dorsoventral and lateral diameters are both 22 mm., three camerae occupy a total length of 10.3 mm. ventrally. The surface of the shell is wrinkled and striated transversely, both wrinkles and striae curving moderately downward in a ventrad direction along the dorsolateral parts of the conch, this curvature increasing ventrolaterally, being greatest on approaching former locations of the hyponomic sinus. The transverse wrinkles are fairly distinct between 120 and 150 mm. back from the aperture, and are relatively obscure both in an apical direction and toward the aperture. Even where best developed they are distinct only ventrolaterally, become less distinct dorsolaterally, and are faint or obsolete along the median part of the ventral side of the conch. The hyponomic sinus is broadly rounded, slightly V-shaped, and almost 15 mm. in depth below its dorso-lateral margins.

Occurrence.—Lot 4, concession 3, R.F., Gloucester township, Carleton county, southeast of Ottawa, Ontario, Canada. In the Black River. Holotype, no. 7391, National Museum of Canada.

Remarks.—This specimen evidently is closely related to *Plectoceras halli*, Foord,² from Lorette, near Quebec, Canada. Compared with that one of the two cotypes figured by Foord, the Carleton county specimen is much more weakly annulated. A similar comparison can be made with the figures presented by Whiteaves, based on other specimens from the type locality.

² *Trochoceras Halli* Foord, Cat. Sil. Foss. Ceph. British Museum, pt. 2, 42, figs. 4 a, b, (1891).

Plectoceras Halli Whiteaves, Geol. Surv. Canada, Paleozoic Fossils, 3, pt. 4, 302, pl. 35, figs. 3, 4, 4a, (1906).

EHLERSOCERAS Gen. nov.

Genotype.—*Ehlersoceras huronense* Foerste.

Conch breviconic, moderately curved lengthwise, slightly depressed, the dorsal and ventral sides of its cross-section being less strongly convex than its lateral parts. Siphuncle small, located near the ventral wall of the conch but not in contact with the latter. Surface of shell transversely striated, the striae sloping strongly downward along its lateral sides in a ventrad direction; along the ventral side of the conch their downward curvature is moderate. This strong downward slope of the transverse striae in a ventrad direction is the most striking feature of the surface ornamentation.

147. *Ehlersoceras huronense* Sp. nov.

Plate 29, figs. 9 A, B

Specimen 68 mm. long, measured along its convex ventral outline. The radius of curvature of this outline is about 100 mm. The dorsoventral diameter of the conch enlarges from 5.4 mm. at its base to 15.5 mm. at its top. Its lateral diameter is estimated at 6.2 mm. at its base, and the cross-section of the conch is regarded as slightly depressed also farther up, but here the lateral diameter can not be measured. Toward the top of the specimens both the dorsal and ventral sides of the cross-section appear more broadly rounded than its lateral sides. Where its dorsoventral diameter is 8 mm. there are 5.3 camerae in a corresponding length. The sutures of the septa are straight, but slope downward in a ventrad direction at an angle of about 10 degrees with a directly transverse plane. Where the dorsoventral diameter of the conch is 5.4 mm., the center of the siphuncle is 1 mm. from its ventral wall, and its septal foramen is about 0.8 mm. in diameter. The concavity of the septum here is about 0.6 mm. Along the upper part of the conch its shell is about 0.5 mm. thick. The surface of the shell is densely striated with numerous transverse raised lines which are nearly directly transverse dorsally and ventrally but which slope downward across the lateral sides at an angle of 15 degrees with a directly transverse plane. There is no downward

curvature of these striae along the median part of the ventral side of the conch beyond that resulting from the general downward ventrad slope just indicated.

Occurrence.—St. Joseph Island, in the northwestern part of Lake Huron; in the Black River formation. No. 8374, in the museum of the University of Michigan. Collected by Carl Rominger.

MANITOULINOCERAS Foerste

Genotype.—*Cyrtoceras lysander* Billings, Geol. Surv. Canada, Pal. Foss., 1, 161, figs. 146 a-d, (1865). *Manitoulinoceras lysander* Foerste, Memoir 138, Geol. Surv. Canada, 230, pl. 41, figs. 4 a-f (1924).

Conch depressed dorsoventrally, slightly curved lengthwise, dorsal side slightly flattened, rate of enlargement of conch very small. Sutures of septa almost straight or curving only faintly downward laterally, but rising at an increased angle in a ventrad direction on approaching the upper part of the phragmacone. Siphuncle moniliform in outline, almost in contact with the ventral wall of the conch.

Cyrtoceras postumius Billings differs from the genotype of *Manitoulinoceras* in the much greater curvature of its conch lengthwise, and in its more rapid rate of enlargement. In fact, it scarcely is congeneric with the latter genus, but not sufficient is known of its structure to warrant at present the erection of a new genus.

The species described here as *Manitoulinoceras canadense*, *M. wykoffense*, and *M. warsawense* may be related to *Cyrtoceras postumius*. They resemble the latter in the strong curvature of the conch lengthwise, and in the relatively rapid rate of enlargement of their conchs. The dorsal side of their cross-sections is slightly flattened, and the sutures of their septa tend to rise at an increasing rate in a ventrad direction on approaching the top of the phragmacone. In *Manitoulinoceras canadense* the median part of the ventral side is faintly angulate, and the sutures of the septa here form slightly angulate saddles. In *Manitoulinoceras wykoffense* the ventral saddles are similarly angulate, but the ventral side of the cross-section appears more evenly rounded. Ap-

parently this is true also of the ventral side of the cross-section of *Manitoulinoceras warsawense*.

Provisionally *Cyrtoceras postumius* Billings, and the three species here described as *Manitoulinoceras canadense*, *M. wykoffense*, and *M. warsawense* are placed as a subgeneric group in the genus *Manitoulinoceras*, but in the belief that eventually they will be separated. Unfortunately it is not definitely known at present that they are congeneric with each other, and additional material will be needed to secure sufficient information to form a basis for intelligent discrimination of these forms from typical *Manitoulinoceras* and from each other. From *Loganoceras* they are distinguished by the faint flattening of the ventral part of the cross-section of the conch, and the corresponding tendency toward a slight depression dorsoventrally.

148. *Manitoulinoceras* (?) *canadense* sp. nov.

Plate 25, figs. 8 A, B

Specimen 50 mm. long, measured along its ventral outline. Its dorsal outline has a radius of concave curvature of 24 mm., and that of the convex ventral outline is estimated at 35 mm., the dorsoventral diameter of the conch enlarging from 8.7 mm. near its base to 15 mm. at the top of the phragmacone 30 mm. farther up, and to approximately 17.5 mm. at the aperture, the length of the living chamber being 17 mm. The corresponding lateral diameters are almost identical, but the ventral part of the cross-section of the conch is faintly angular and its dorsal side is slightly flattened, so that the lateral diameter appears very slightly longer than the dorsoventral one. The number of camerae in a length equal to the diameter of the conch increases from 7.5 at the lower end of the specimen to 8.5 at the top of the phragmacone. The sutures of the septa rise at an increasing rate from the dorsal toward the ventral side of the conch, the ventral saddles being about 1 mm. above the level of the dorsal part of the same sutures. The median part of these saddles is faintly angular. The siphuncle is located almost in contact with the ventral wall of the conch.

Occurrence.—La Petite Chaudiere, opposite Ottawa, Canada; in the Black River formation. Holotype, no. 1296a, National Museum of Canada.

149. *Manitoulinoceras* (?) *wykoffense* Sp. nov.

Plate 25, figs. 7 A, B

Cyrtoceras neleus Clarke, Geol. Minnesota, 3, pt. 2, 804, pl. 59, figs. 17–19 (1897).

Holotype 103 mm. long, measured along its ventral outline. The radius of curvature of its concave dorsal outline varies from 20 mm. along the lower third of the specimen to 30 mm. along its upper half. Its dorsoventral diameter increases from 7.5 mm. near its lower end to 14.5 mm. at the base of the living chamber, its lateral diameter here equalling 15 mm. The living chamber apparently was at least 18 mm. long, but its upper margin is poorly defined. The dorsal side of its cross-section appears more broadly rounded than its ventral side. Where the lateral diameter of the conch is 15 mm. there are 6.5 camerae in a corresponding length along its ventral outline. The sutures of the septa are directly transverse along the middle of the dorsal side of the conch but rise increasingly in a ventrad direction, attaining a level 2.5 mm. higher ventrally than dorsally at the top of the phragmacone. The siphuncle either is in contact or almost in contact with the ventral wall of the conch. Its segments are almost 2.5 mm. in diameter along the upper part of the phragmacone. No trace of the surface of the shell is preserved.

Occurrence.—Wykoff, Minnesota; in the Prosser member of the Trenton. No. 4117, in the Robbins collection of the University of Minnesota.

Remarks.—In typical *Manitoulinoceras neleum* (Hall), the rate of enlargement of the conch is much less, the conch is slightly compressed laterally, and the camerae are slightly more numerous.

150. *Manitoulinoceras* (?) *warsawense* Sp. nov.

Plate 25, figs. 3 A, B

Cyrtoceras corniculum Clarke, Geol. Minnesota, 3, pt. 2, 809, pl. 59, figs. 16, 16a, (1897).

Holotype 29 mm. in length along its convex ventral outline. The radius of curvature of this outline is about 15 mm., enlarging slightly toward its top. Its dorsoventral diameter enlarges from 2 mm. at its base to 6 mm. at mid-length, and to 7.9 mm. at its top. The corresponding lateral diameters are 2 mm., 7 mm., and 10 mm., the diameter at its top being estimated from that part of the cross-section preserved. This cross-section is depressed elliptical, with the dorsal side slightly flattened. The only septum exposed is that at the top of the specimen, and this rises at an angle of 20 degrees with the horizontal in a ventrad direction. Its suture is straight. The concavity of the septum is slight. The passage of the siphuncle through the septum appears to be 0.5 mm. in diameter and to be located 0.5 mm. from the ventral wall of the conch. The surface of the shell apparently was smooth.

Holotype.—Warsaw, Minnesota; in the Decorah member of the Black River. No. 4116, in the Scofield collection, in the museum of the University of Minnesota.

Remarks.—In its lengthwise curvature, rate of enlargement, and ventral rise of the sutures of the septa this form closely resembles *Loganoceras regulare* (Billings), but it differs in the flattening of the dorsal side of the conch. *Cyrtoceras corniculum* Hall, later changed to *Cyrtoceras tenuistriatum* Hall, is distinctly and closely striated in a directly transverse direction, except along the median part of the ventral side where the striae curve distinctly, though moderately downward, indicating the presence of a shallow hypomic sinus.

ROMINGOCERAS Gen. nov.

Genotype.—*Romingoceras josephianum* Foerste.

Conch slowly enlarging, strongly curved lengthwise, possibly gyroceraconic, but only one-third of a volution remains in the largest fragment at hand. The latter shows no trace of a contact area. The cross-section is moderately depressed dorsoventrally, its dorsal side being slightly less convex than its ventral one. Its siphuncle is relatively small and near the ventral wall of the conch, but not in contact with the latter. Its segments are oblong, and distinctly longer than broad. Its transverse striae curve only

slightly downward along the median part of the ventral side of the conch, indicating a very shallow hyponomic sinus.

151. *Romingeroceras josephianum* Sp. nov.

Plate 29, fig. 5

Specimen 50 mm. long, measured along its convex ventral outline; strongly curved lengthwise. The radius of curvature of this ventral outline is 22 mm. The upper end of the specimen is regarded as including the living chamber, whose length, however, can not be determined. The dorsoventral diameter of the conch increases from 9 mm. at its base to 10 mm. at its top, the corresponding lateral diameters being 10 mm. and 11 mm. The dorsal side of its cross-section is distinctly more broadly rounded than its lateral parts, and the median part of its ventral side is faintly more narrowly rounded than its ventrolateral parts. The sutures of the septa are straight but slope downward in a ventrad direction at an angle of 5 degrees with a directly transverse plane. The concavity of the septum at the base of the specimen is about 1 mm. The center of the siphuncle is 1 mm. from the ventral wall of the conch, its diameter being about 1 mm. The surface of the shell is transversely striated, the striae being relatively numerous and curving slightly downward along the median part of its ventral side, somewhat as in *Zitteloceras tenuistriatum* (Hall). No. 14485. Plate 29, fig. 5.

Another fragment from the same locality is 15 mm. long and has a lateral diameter of 10 mm. It includes 8 camerae in a corresponding length, measured along its ventral outline. The segments of the siphuncle have been exposed and are 1 mm. in diameter. No. 14486.

Occurrence.—St. Joseph Island, in the northwestern part of Lake Huron; in the Black River. Collected by Carl Rominger, and numbered 14485, 14486, in the museum of the University of Michigan.

STAUFFEROCERAS Gen. nov.

Genotype.—*Cyrtoceras featherstonhaughi* Clarke, Geol. Minnesota, 3, pt. 2; 807, pl. 58, figs. 12-15, (1897).

Conch relatively short; moderately curved lengthwise, chiefly along its ventral outline; strongly depressed dorsoventrally, the dorsal side flattened, the ventral side more convex. Living chamber slightly contracted toward the aperture. Sutures of septa horizontal dorsally, rising at an increasing rate in a ventrad direction on approaching the upper end of the phragmacone. Siphuncle located near the ventral wall of the conch, possibly in contact with the latter.

152. *Staufferoceras featherstonhaughi* (Clarke)

Plate 29, figs. 6 A, B, C

Cyrtoceras featherstonhaughi Clarke, Geol. Minnesota, 3, pt. 2, 807, pl. 58, figs. 12-15 (1897).

Specimen 38 mm. long, measured along its convex ventral outline; of this length 15 mm. is occupied by the living chamber. The radius of curvature of this ventral outline is 40 mm., that of the corresponding concave dorsal outline also being 40 mm. along the greater part of the length of the phragmacone, but changing to an almost straight outline along the top of the phragmacone and the entire length of the living chamber. The conch is strongly depressed dorsoventrally. Its lateral diameter increases from 8 mm. at its base to 13 mm. at the base of the living chamber, and to 14.3 mm. at a point 5 mm. farther up, thence contracting slightly toward the aperture. The corresponding dorsoventral diameters are 6 mm., 10.8 mm., and 11.8 mm., also contracting faintly farther up. The original length of a complete specimen, including both the phragmacone and living chamber, is estimated at 60 mm. The ventral and ventrolateral parts of the conch present an almost semi-circular cross-section, but the cross-section of its dorsal side is much less strongly convex, appearing relatively flat. There is a slight tendency toward angularity along the dorsolateral parts of the conch. The number of camerae within a length equal to the lateral diameter of the conch varies from nearly 6 along the lower part of the specimen to nearly 7 along the upper part of the phragmacone. Along the lower part of the specimen the sutures of the septa are almost directly transverse, except

ventrally where they rise slightly. However, toward the top of the phragmacone the sutures rise at an increasingly greater rate toward this ventral side, producing successively more prominent ventral saddles, slightly angular along their median parts. Moreover, there is also a faint elevation of these sutures along the median part of the dorsal side of the phragmacone, resulting in very faint but broad dorsal saddles. Where the lateral diameter of the conch is 12 mm. the lateral concavity of the septa has a radius of 12 mm., the concavity in a dorsoventral direction having a radius of about 7 mm. The siphuncle either is almost in contact with the ventral wall of the conch, or touches it but slightly. Its diameter at the point here designated is 1.5 mm. Apparently its segments contract at the septal necks, resulting in a moniliform succession of more or less rounded segments. Only the cast of the interior of the conch is preserved, and this presents no trace of surface striae. This surface, apparently, was smooth.

Occurrence.—Cannon Falls, Minnesota; in the Platteville member of the Black River. No. 4123, in the collection of W. H. Scofield, belonging to the University of Minnesota. Holotype.

SCOFIELDOCERAS Gen. nov.

Genotype.—*Cyrtoceras shumardi* Clarke, Geol. Minnesota, 3, pt. 2, 810, pl. 60, figs. 1-4, (1897).

Conch definitely known only from a single living chamber, which may be distorted at its top, but this chamber indicates a conch relatively short, rapidly enlarging, and probably strongly curved lengthwise. The cross-section is distinctly depressed dorsoventrally. Siphuncle apparently small and located one-fifth of the dorsoventral diameter of the conch from its ventral side. In its present condition the ventral outline of the living chamber appears geniculate at two-sevenths of its length from the top of the chamber. Possibly the lower five-sevenths of its outline was flattened by pressure, thus accounting for the abnormal geniculate appearance farther up.

The relatively small size of the siphuncle at its passage through the septum, and its distinct distance from the ventral wall of the conch are its most distinctive characteristics.

153. *Scofieldoceras shumardi* Sp. nov. (Clarke)*Plate 29, figs. 11 A, B*

Cyrtoceras shumardi Clarke, Geol. Minnesota, 3, pt. 2, 810, pl. 60, figs. 1-4 (1897).

Living chamber 27 mm. in length along its convex ventral outline, strongly depressed dorsoventrally. Along this ventral outline its radius of curvature is 70 mm. for a length of 19 mm., changing to 10 mm. farther up. Along the corresponding dorsal outline its radius of concave curvature changes from 40 mm. along the lower 8 mm. of its length to 10 or 15 mm. farther up. In consequence, the upper part of this living chamber is humped and appears bent in a dorsad direction. It can not be determined, however, from the single specimen at hand whether this humping of the upper part of the living chamber was characteristic of the conch during the life of the animal or was due to distortion after its death. At any rate, the upper part of this chamber is wrinkled ventrally at and above this hump, while smoother farther down. At the base of the chamber its lateral diameter is 19 mm. and its dorsoventral one is 15 mm. At a point 16 mm. above the suture of the septum at its base, measured laterally, the lateral diameter of this chamber is 25 mm. and its dorsoventral diameter is estimated at 22 mm. Above the level of the hump the rate of enlargement of the conch is much less. Judging from the rate of enlargement of the lower part of the living chamber, the phragmacone of this specimen probably was a little less than 50 mm. in length, so that the total length of the conch may have been 75 mm. The margin of the aperture slopes downward in a dorsad direction. The suture of the septum at the base of the living chamber is straight, but rises slightly in a ventrad direction. The concavity of this septum is 5 mm. The location of the siphuncle is not known with certainty, but there is a slight elevation on the lower surface of the septum mentioned, about 1 mm. in diameter, and 3 mm. distant from the suture of this septum when measured along the curvature of the latter. Its distance from the nearest part of the shell of the complete conch probably was about 2 mm. The chief reason for regarding this elevation as a remnant of the

siphuncle is the absence of any other marking which can be interpreted as such.

Occurrence.—Cannon Falls, Minnesota, in the Platteville member of the Black River. No. 4134, in the collection of W. H. Scofield, belonging to the University of Minnesota. Holotype.

154. *Scofieldoceras* (?) *depressum* Sp. nov.

Plate 29, fig. 10

Specimen 20 mm. long, measured along its ventral outline; strongly depressed dorsoventrally. Its lateral diameter enlarges from 2.5 mm. at its base to 9 mm. at a point 15.5 mm. farther up, the corresponding dorsoventral diameters being 2.3 mm. and 7 mm. The radius of curvature of its convex ventral side is about 13 mm. At the base of the specimen, where its dorsoventral diameter is 2.3 mm., the diameter of the siphuncle is 0.5 mm., and its distance from the ventral wall of the conch is about 0.25 mm. Faint transverse lines along the upper part of the specimen are directly transverse, with no perceptible indication of a hyponomic sinus.

Occurrence.—Warsaw, Minnesota; in the Decorah member of the Black River formation. Associated with *Manitoulinoceras* (?) *warsawense* Foerste at that locality. No. 4133, Univ. of Minnesota.

FAYETTOCERAS Gen. nov.

Genotype.—*Cyrtoceras thompsoni* Miller, 18th Ann. Rep. Indiana Dep. Geol. Nat. Res., 323, pl. 10, figs. 7, 8 (1894).

Conch moderately curved lengthwise, with the siphuncle located on its convex ventral outline; depressed dorsoventrally. The concavity of the septa is slight. The siphuncle is close to the ventral wall of the conch, but not in contact. Its segments appear oval, moderately elongated in a vertical direction, and strongly contracted at the septal necks. The surface of the shell is striated transversely. These striae are directly transverse along the entire circumference of the conch, except possibly along the median part of its ventral side, where the striae are not clearly exposed, but possibly curve faintly downward.

155. *Fayettoceras thompsoni* (Miller)*Plate 31, figs. 6 A, B*

Cyrtoceras thompsoni Miller, 18th Ann. Rep. Indiana, Dep. Geol. Nat. Res., 323, pl. 10, figs. 7, 8 (1894).

Only a fragment of the phragmacone is known. This is 43 mm. in length when measured along the curvature of its ventral side. The radius of convex curvature of this side is 100 mm., that of its concave dorsal side being about the same. Its dorsoventral diameter increases from about 18 mm. at the base of the fragment to 27 mm. at its top, the interval being 43 mm. The corresponding lateral diameters are 20 mm. and 30 mm., the conch being depressed dorsoventrally. The lower 12 camerae occupy a total length of 30 mm. along the ventral outline of the conch. The upper 6 camerae occupy a total length of 12 mm., becoming successively shorter toward the top of the specimen, indicating that the latter represents the upper end of a phragmacone which had reached its gerontic stage. The sutures of the septa are relatively straight. The concavity of the septa is slight, its radius of curvature being 40 mm. at the top of the specimen. The siphuncle, at its base, enlarges from 1 mm. at its septal neck to nearly 3 mm. at midheight within the overlying camera, its segment being nearly globular in form, but slightly elongated vertically. The surface of the shell is striated transversely, the striae being relatively faint, the general aspect of this surface being smooth. There is a possibility that these striae curve faintly downward along the median part of the ventral side of the conch.

Occurrence.—Longwood, Indiana; in the upper part of the Richmond, presumably from its Whitewater division. No. 64334, U. S. National Museum.

156. *Fayettoceras* (?) *beloitense* Sp. nov.*Plate 34, figs. 3 A, B*

Holotype 37 mm. long along its ventral outline, depressed dorsoventrally. A part of this depression evidently is due to compression since the death of the animal, but a part may have been present originally. In its present condition the lateral diameter

of the conch enlarges from 19.5 mm. at its base to 37.5 mm. at a point 29 mm. farther up, measured along its lateral sides. The corresponding dorsoventral diameters are estimated at 18 mm. and 30 mm. The conch apparently is more broadly rounded dorsally than ventrally. The rapid enlargement of the conch suggests *Rizoceras*, but the dorsoventral compression excludes this relationship. The conch is curved lengthwise, its convex ventral outline having a radius of curvature of approximately 80 mm. The ventral outline is assumed to have been correspondingly concave. The phragmacone is 16 mm. in length along its ventral outline, and at its top the lateral outline is 28 mm., and its dorsoventral outline is estimated at 24 mm. Along this ventral outline 7 camerae occupy a length of 16 mm., suggesting 12 or 13 camerae in a length equal to the lateral diameter. The sutures of the septa along the upper 4 camerae are straight and rise slightly ventrally. Along the median part of the ventral side of the conch they are slightly angulate, forming very low saddles. Along the dorsal side they are directly transverse. Along the lower part of the specimen these sutures curve slightly downward; the septa here curve slightly more in a dorsoventral direction than laterally. The siphuncle appears to be in contact with the ventral wall of the conch along the lower part of its segments. At the base of the specimen the siphuncle is 4 mm. in diameter, and apparently narrows strongly at the septal necks. The surface of the shell is transversely striated, about 7 striae occurring in a length of 2 mm. These striae appear to be directly transverse dorsally, but slope moderately downward ventrally, forming an angle of about 12 degrees with the upper sutures of the septa along the ventrolateral part of the conch, indicating a very shallow and broad hyponomic sinus.

Occurrence.—Beloit, Wisconsin; Platteville member of the Black River. Holotype, no. 15680, U. S. National Museum.

Remarks.—This species is characterized by the rapid enlargement of its conch, the closeness of its siphuncle to the ventral wall of the conch, and the small rise of the sutures of its septa in a ventrad direction, the median part of their course ventrally being slightly angulate. In its present condition the conch appears

conspicuously depressed, but a large part of this depression may be due to dorsoventral flattening after the death of the animal.

PROBILLINGSITES Foerste

Genotype.—*Probillingsites welleri* Foerste, Jour. Sci. Labs. Denison Univ., 23, 318, pl. 71, figs. 2 A, B (1928).

In *Billingsites* the sutures of the septa rise from the ventral side of the base of the bulb-like gerontic expansions in a dorsad direction at an angle of about 45 degrees with the horizontal for a distance equal to approximately half the dorsoventral diameter and then curve abruptly upward and more or less ventrad for a conspicuous distance before resuming their course in a dorsad direction. The upper parts of the saddles thus formed cross the dorsal side of the conch in an almost horizontal direction. The convexity of the dorsal outline often is slightly greater at mid-height of the bulb-like expansions than the ventral outline, but above the level of the uppermost dorsal saddle it frequently is distinctly, though moderately, concave.

In *Probillingsites* the sutures of the septa rise at different angles along their entire course from the ventral toward the dorsal side of the bulb-like expansions of the conch, although their course may be slightly sinuous. Conchs of this type make their appearance earlier than typical *Billingsites*, apparently already in the Platteville member of the Black River, though congeneric species are associated with the latter as late as the upper part of the Richmond.

157. *Probillingsites* sp. (Cornell)

Plate 29, figs. 8 A, B

Specimen 47 mm. long, consisting of a gerontic oviform enlargement of the upper end of a conch, including a living chamber, 3 distinct camerae, and a lower undivided part which originally may have consisted of 2 additional camerae. The sutures of the three camerae slope obliquely downward from the dorsal toward the ventral side of the conch, becoming more closely crowded in that direction. The upper part of the dorsal outline is moderately concave.

Cornell, 13 miles northwest of Escanaba, Michigan, in the Trenton. No. 14459, in the museum of the University of Michigan.

CYRTOCERINA Billings

Genotype.—*Cyrtocerina typica* Billings, Geol. Surv. Canada, Pal. Foss., 1, 178, text fig. 159 (1865).

Conch short, rapidly enlarging, curved lengthwise, endogastric in structure, its siphuncle being located near the concave ventral side of the conch, its dorsal outline being convex. Cross-section oval, with its convex dorsal side more narrowly rounded. Camerae relatively short and numerous, straight or slightly concave laterally, diverging in a dorsad direction. Segments of siphuncle enlarging within the camerae, apparently ellipchoanoidal in structure, rather than holochanoidal. Structure of siphuncle requiring further investigation.

Cyrtocerina mercurius Billings, having a siphuncle of holochanoidal structure, is the genotype of *Levisoceras* Foerste.

158. *Cyrtocerina schoolcrafti* Clarke

Plate 32, figures 10 A-C

Cyrtocerina (?) *schoolcrafti* Clarke, Geol. Minnesota, 3, pt. 2, 774, pl. 47, figs. 12-14 (1897).

Specimen 8 mm. long on its convex outline, and 4.5 mm. long on its concave one. The radius of curvature of its convex outline is about 12 mm. The concavity of its opposite outline is only faint. Its dorsoventral diameter enlarges from 5 mm. at its base to 10.3 mm. at its top. The corresponding lateral diameters are 4 mm. and 8.9 mm. The cross-section is oval, the siphonal or concave side being distinctly more broadly rounded, while the antisiphonal side tends to be angular, the angularity increasing toward the top of the specimen. The septa are closely crowded, their number being probably about equal to the black ink lines drawn across one of its lateral sides. The sutures of the septa are apparently straight, but diverge from each other toward the antisiphonal side of the conch. The concavity of the septum at its top is only slightly over 1 mm. The siphuncle increases in diameter from

almost 1 mm. at its base to 1.5 mm. at its top. The surface of the shell is finely striated, about 7 to 9 striae in a length of 1 mm. These striae are parallel to the sutures of the septa, and do not curve downward along the median part of either the siphonal or antisiphonal side of the conch.

Cannon Falls, Minnesota; in the Decorah member of the Black River. No. 46526, U. S. National Museum. Holotype.

Remarks.—This appears to be a typical species of *Cyrtocera*. It is assumed to have been a small form, but it may have grown to much larger proportions.

ULRICHOCERAS Foerste

Genotype.—*Ulrichoceras beloitense* Foerste, Jour. Sci. Labs. Denison Univ., 23, 211, pl. 47, figs. 1 A-C; p. 320, pl. 52, fig. 4 (1928).

Conch moderately gomphoceroid in appearance, owing to the moderate contraction of the upper part of the conch. Sutures of septa approximately directly transverse along the dorsal half of the circumference of the conch, but curving conspicuously downward ventrally, forming broad ventral lobes. The siphuncle is located halfway between the center of the conch and its concave ventral outline, and its segments are nummuloidal.

159. *Ulrichoceras beloitense* Foerste

Ulrichoceras beloitense Foerste, Jour. Sci. Labs. Denison Univ., 23, 211, pl. 47, figs. 1 A-C; p. 320, pl. 53, fig. 4 (1928).

Holotype about 50 mm. long along its convex dorsal outline, the radius of curvature of this outline changing from 100 mm. along the lower three-fourths of the conch to approximately 60 mm. along its upper fourth. The dorsoventral diameter enlarges from 21 mm. at its base to 31 mm. at a point 35 mm. farther up, and then continues at this diameter for an additional distance of 15 mm. The corresponding lateral diameters are 22.5 mm., 32.5 mm., and again 32.5 mm. While the conch does not actually contract toward its aperture, its failure to enlarge there gives it an appearance of contraction. The concave ventral side of the conch is slightly more depressed than its dorsal part. The radius of its curvature is about 70 mm. along the lower two-thirds of the

length of the conch, above which the curvature becomes less concave. Laterally the uppermost suture of a septum is about 19 mm. above the base of the specimen. Dorsally these sutures are almost directly transverse, but ventrally they curve downward 7 or 8 mm., forming broad ventral lobes whose basal parts are almost 8 mm. in width. The lateral diameter of the conch at the top of its phragmacone is 30 mm., its dorsoventral diameter here being 27 mm. Eight camerae are preserved in the immediately underlying part, 20 mm. in length laterally, suggesting 12 camerae in a length equal to the lateral diameter of the conch. At the base of the specimen, where its dorsoventral diameter is 21 mm., the center of the siphuncle is 6 mm. from the ventral side of the conch. Its segments here are 4.5 mm. in diameter, contracting to about 2 mm. at the septal necks. Their general form is nummuloidal. The specimen is a cast of the interior of the conch and no trace of the surface ornamentation remains.

Occurrence.—Beloit, Wisconsin; Upper Buff member of the Beloit formation, in the Black River group. Holotype, no. 25302, U. S. National Museum.

TEICHERTOCERAS Gen. nov.

Genotype.—*Teichertoceras husseyi* Foerste.

Conch moderately curved lengthwise, endogastric, its antisiphonal side evenly convex, not humped along the upper part of the phragmacone, its siphonal side concave along the lower half of the phragmacone, but distinctly gibbous farther up. Living chamber only partially preserved, but apparently contracted toward the aperture. Sutures of the septa curved downward laterally, forming broad saddles across the antisiphonal side of the conch but angulate saddles along the median part of the siphonal side. Siphuncle exposed on the weathered side of the genotype. Similar in structure to the siphuncle of *Westonoceras*, and located, in a similar manner, near but not in contact with the ventral wall of the conch, but this ventral wall has a concave outline, instead of a convex one, as in that genus.

The sectioned specimen figured by Clarke from Minnesota under the name *Oncoceras minnesotense* (Geol. Minnesota, 3, pt. 2, 799,

fig. 10 (1897)) here is referred to *Teichertoceras* on account of its slightly concave siphonal outline. The general form of its conch is unknown.

160. *Teichertoceras husseyi* Sp. nov.

Plate 33, figs. 2 A, B

Specimen 128 mm. long, with an endogastric siphuncle. Its antisiphuncular outline has a radius of curvature of 200 mm. along the phragmacone. Its outline on the side nearest the siphuncle has a radius of concave curvature of 100 mm. for a length of 50 mm., reversing along the upper part of the phragmacone to a radius of convex curvature of about 80 mm. Although one of the lateral sides of the living chamber is preserved for a length of 30 to 35 mm., nothing definite is known of either its siphuncular or antisiphuncular outline. The conch not only is gibbous along its siphuncular outline but also laterally, its lateral diameter increasing upward as far as the fourth camera beneath the living chamber, above which it contracts not only along the remainder of the phragmacone, but also along that part of the living chamber which is preserved. Six of the upper camerae are each about 5 mm. long, but the uppermost one is only 3 mm. long, suggesting that the conch had reached full maturity. At the lower end of the specimen, where its dorsoventral diameter is 15 mm., 6 camerae occur in a corresponding length; at a diameter of 23 mm. there are 7 camerae, and at one of 36.5 mm. there are 7.5 camerae. The sutures of the septa curve downward laterally. Along the lower part of the phragmacone this downward curvature is slight, but along its upper end it equals 4 or 5 mm. Along the lower part of the phragmacone the sutures rise to a higher level along the antisiphonal side of the conch than along its siphonal side, but along its upper part the sutures rise higher along its siphonal side. Where the dorsoventral diameter of the conch is 19 mm., that of the siphuncle is 3.6 mm. and its distance from the nearest wall of the conch is 2 mm. Its diameter at the septal neck is estimated at 1.2 mm. The length of this septal neck is one-fourth of a millimeter and its brim is reflected upward until apparently in contact with the lower face of the septum from which it originates.

That side of the connecting rings which faces the concavely curved wall of the conch is nearly straight in vertical outline, while its opposite side is moderately convex. About 45 mm. above the base of the specimen, where its dorsoventral diameter is 28.5 mm., the cast of the interior of the conch retains 4 low, vertical ribs in a width of 4.8 mm., suggesting about 45 ribs within the circumference of the conch. The surface of the shell directly beneath this level is smooth.

Occurrence.—Cornell, Michigan, 13 miles northwest of Escanaba; in the Trenton. Holotype, no. 14461, in the museum of the University of Michigan.

161. *Teichertoceras* cf. *husseyi* Sp. nov.

Plate 33; figs. 4 A, B

Oncoceras minnesotense Clarke, Geol. Minnesota, 3, pt. 2, 799, text-fig. 10 (1897).

Westonoceras minnesotense Foerste, Jour. Sci. Labs. Denison Univ., 24, 312, pl. 48, fig. 4 (1929).

The siphonal side of this specimen appears slightly concave in vertical outline, while its antisiphonal side is slightly convex. The brim of the septal necks is abruptly reflected outward so as to be adnate to the lower face of the overlying septum for its entire width, as in typical *Westonoceras*. The cross-section of the conch is oval, its siphonal side being more narrowly curved, and the saddles of the septa on this side being distinctly angular along its median line, while the saddles on its antisiphuncular side are more broadly curved. As far as can be determined from such a small fragment this specimen could belong to the same species as *Teichertoceras husseyi*. The name *Teichertoceras* (?) *clarkei* Foerste (Jour. Sci. Labs. Denison Univ., 27, description of Pl. 33, figs. 4 A, B) here is dropped.

Occurrence.—Lime City, Minnesota; from the same locality and horizon as *Westonoceras minnesotense*. No. 258 B, in the museum of the University of Minnesota.

DIESTOCERAS Foerste

Genotype.—*Gomphoceras indianense* Miller and Faber, Jour. Cincinnati Soc. Nat. Hist., 17, 137, pl. 7, figs. 3-5, (1894);

Diestoceras indianense Foerste, Jour. Sci. Labs., Denison Univ., 20, 263, pl. 25, figs. 1 A, B; pl. 26, figs. 1 A, B, 2 A, B; pl. 27, Fig. 2 (1924).

Conch relatively erect, practically without lengthwise curvature, though possibly faintly curved in its initial stages. Ventral and dorsal outlines almost equally convex. Living chamber contracting toward the aperture, the outlines of this aperture somewhat angulate on its ventral side, thus locating the hyponomic sinus. The siphuncle is located close to the ventral side of the conch. Its location is assumed to be endogastric. The transverse striae on the surface of the conch curve slightly but distinctly downward along the median part of its ventral side.

Diestoceras staufferi finds its nearest relationship in the group of species typified by *Diestoceras nobile* (Whiteaves), in which the vertical outlines are quite strongly convex both laterally and dorsoventrally, giving the living chamber a strongly convergent, almost hemispheric appearance. This group is characteristic of the Red River formation as exposed in southern Manitoba, and in corresponding strata in Montana.

In *Diestoceras cornellense* the upper part of the living chamber changes from distinctly contracting to more erect vertical outlines on approaching the aperture.

In *Diestoceras romingeri* the conch is more compressed laterally, the contraction of the upper part of the living chamber being more moderate. Its relationship appears to be with *Diestoceras alceum* (Hall), from the Black River of Beloit, Wisconsin, *Diestoceras tyrrelli* (Parks), from the Shammattawa limestone of the Hudson Bay area, and such species as *Diestoceras vagum* Foerste, *Diestoceras carletonense* Foerste, and *Diestoceras anticostiense* Foerste from the Richmond of Anticosti.

162. *Diestoceras staufferi* Sp. nov.

Plate 34, figs. 1 A, B

Cf. *Diestoceras* sp. Foerste, Jour. Sci. Labs. Denison Univ., 24, 228, pl. 35, fig. 1 (1929).

Cf. *Diestoceras whiteavesi* Foerste, *idem*, 226, pl. 35, fig. 2 (1929).

Specimen 85 mm. long, enlarging from a dorsoventral diameter of about 23 mm. at its base to 63 mm. at the base of the living

chamber 47 mm. farther up, and to 40 mm. at the aperture, the living chamber being 37 mm. in height. The lateral diameter can not be determined with accuracy but is estimated to have been about 58 mm. at the base of the living chamber. The dorsal and ventral vertical outlines are slightly different. The height of the living chamber is less dorsally than ventrally, except at the hyponomic sinus. The dorsal outline has a radius of curvature of 60 mm., except along its lower 3 camerae, where it is less convex. The ventral outline has a radius of curvature of 40 mm. along the living chamber, changing to 60 mm. along the upper and middle part of the phragmacone, and apparently reversing to slightly concave along the lower 3 camerae. The septum at its base is strongly concave, considering its small diameter. Between 3 and 7 or 8 mm. above the suture at its base the cast of the interior of the living chamber is transversely grooved, the groove being about 1 mm. deep, and vertically ribbed, at the rate of 7 ribs in a width of 20 mm. The upper 3 camerae have a total length of 18 mm. and the underlying 3 are almost of the same length, measured vertically.

The margin of the aperture of this specimen curves strongly inward and downward for a width of 3 mm. and a depth of scarcely 1 mm. This margin is thickened for a width and height of almost 2 mm., its upper edge presenting a rectangular, sharply crested cross-section, while its inner and lower parts are rounded. The aperture is oval in outline, its more narrowly rounded part being regarded as locating the hyponomic sinus.

Occurrence.—Near the Stone School, in district no. 142, in Filmore County, Minnesota; in the Maquoketa member of the Richmond formation. No. 4099, in the museum of the University of Minnesota.

Remarks.—Compared with *Diestoceras whiteavesi* Foerste, from the lower or Dog River member of the Red River formation, this species is more turbinate in vertical outline. Compared with *Diestoceras gibbosum* Foerste, from the upper or Selkirk member of this formation, the conch is less broadly expanded at the top of the phragmacone and base of the living chamber.

The incurved parts of the shell at the aperture in the Minnesota

specimen are sharply defined, while the corresponding parts of figures 1 and 2 of plate 35, cited above, appear to have received their outlines, at least in part, from the tools of the cleaner. At least, these outlines appear so poorly preserved within the rock that it seems impossible to get at a more satisfactory knowledge of their course by additional work on the original specimens.

163. *Diestoceras cornellense* Sp. nov.

Plate 35, figs. 3 A, B

Specimen 43 mm. long, presenting a globose appearance along its lower three-fourths, but strongly contracted along its upper fourth. The living chamber is 28 mm. long, and presents a maximum lateral diameter of 38 mm. and a dorsoventral one of 40 mm. at about 5 or 6 mm. above its base. At its aperture the lateral diameter is 29 mm., and originally its dorsoventral diameter probably was contracted to the same degree, but at present the upper part of the dorsal side of this chamber is crushed in, evidently owing to pressure after the death of the animal. Along the upper 8 to 10 mm. of the chamber its vertical outlines are faintly concave, at least along the surface of the cast of the interior of the conch. The aperture of the living chamber was broadly ovate in outline, its ventral margin being distinctly more narrowly rounded, and possibly slightly curved downward, suggesting a hyponomic sinus. The uppermost camera varies in length from 2.5 mm. along its dorsal outline to 3.5 mm. along its ventral one. The camera next beneath probably was of equal length. The septum of this second camera presents a concavity of almost 10 mm. The passage of the siphuncle through this septum is about 3.5 mm. in diameter and is located close to the ventral wall of the conch.

Occurrence.—Escanaba River, northeast of Cornell, Michigan; in the Trenton. No. 14416, in the museum of the University of Michigan.

164. *Diestoceras* (?) *romingeri* Sp. nov.

Plate 34, figs. 2 A, B

Specimen 64 mm. long, 41 mm. of this length belonging to the living chamber. Its dorsoventral diameter enlarges from 29 mm.

at its base to 40 mm. at the base of the living chamber which is 18.5 mm. farther up, and to 46 mm. at a level 10 mm. farther, above which the rate of enlargement of the conch is conspicuously less, its dorsal outline becoming almost vertical, while its ventral outline, though not preserved, may even curve a little inward. The cross-section of the conch is oval, its ventral part being conspicuously more narrowly rounded than its dorsal part, with its maximum lateral diameter dorsad of the center of the conch. This lateral diameter enlarges from 23.5 mm. at the base of the specimen to 30 mm. at the base of the living chamber. It continues to enlarge at about the same rate to a point 19 mm. above the base of this chamber, and then diminishes a little toward the aperture, but the specimen is not well enough preserved here for exact measurements. Where the dorsoventral diameter of the conch is 40 mm. the underlying 5 camerae have a total length of 18.5 mm., suggesting a total of about 11 camerae in a length equal to this diameter. The sutures of the septa are straight and almost directly transverse. The cast of the interior of the living chamber is crossed by faint annulations at intervals of 4 or 5 mm. These annulations arch upward from 5 to 7 mm. along the upper part of the chamber, and probably are approximately parallel to the margins of the aperture. Dorsally they form broad lobes, but ventrally the lobes are much narrower, suggesting the presence of a relatively deep hyponomic sinus. The lower half of the living chamber and the underlying part of the phragmacone is marked by faint vertical ribs numbering 7 or 8 in a width of 20 mm. along the basal part of the chamber.

Occurrence.—St. Josephs Island, Lake Huron, Ontario; in the Black River. No. 2480, in the museum of the University of Michigan.

Remarks.—This species differs from any other so far referred to the genus *Diestoceras* in its oval cross-section, its ventral side being distinctly more narrowly rounded, and apparently also in the form of its aperture, the margins of the latter arching up laterally, and possessing both a ventral and a dorsal sinus, the ventral one being narrower and corresponding to the hyponomic sinus. It is doubtful whether this specimen is referable to the genus named.

A STUDY OF THE CHANGE IN MASS OF THE ANODE OF THE ALUMINUM-LEAD CELL

CHARLES E. WELLING

Received September 12, 1932; published April 7, 1933

During the last thirty years a number of investigators have studied the phenomena connected with the aluminum-lead cell. Most of the workers have been concerned with the formation of the film (1, 2, 3, 4), the wave form of the current passed (5, 6, 7, 8), optimum operating conditions (9, 10), and the use of the cell as a condenser (11, 12); a small number have attempted studies with the thought of assigning reasons for the phenomena occurring (1, 3, 13). As yet the theories proposed seem to be inadequate (10), largely due to complexity of the subject.

Because of the breadth of the field it was found necessary to restrict the experimental work connected with the present study to the applicability of Faraday's Laws to the small leakage current through an aluminum-lead cell when such a cell is connected across a D.C. source of potential with the aluminum electrode serving as the anode. As has been observed by many workers (2, 3, 4), the aluminum electrode does not possess an infinite resistance when serving as anode although its resistance is very high. In consequence a measurable current is always found to flow in the so-called "cut off" direction.

Guntherschulze (3) explains this phenomenon by assuming diffusion of a gas layer underlying the outside film of more or less highly hydrated aluminum oxide, while Siegmund (12) considers that the oxide layer is constantly dissolving and a new layer forming just below. If the mechanism of this phenomenon involves the solution of Al^{+++} ions in the normal ionic state or of aluminum oxide in some hydrated form then it should be possible to measure the amount of aluminum dissolved either by chemical

analysis of the electrolyte or by determining the loss in weight of the aluminum anode. It has been determined qualitatively that, under some conditions at least, solution (and precipitation after saturation of the electrolyte is reached) does take place and is sometimes so rapid that it is termed corrosion (12).

An attempt was made in the present study to measure the rate of solution of aluminum by determining the loss in weight of the aluminum anode, with the hope of being able to relate the loss quantitatively with Faraday's Laws.

Two aluminum-lead cells, containing about a 2 per cent solution of ammonium phosphate, were used. The lead electrodes were approximately 2 x 10 cm. (that part in contact with the electrolyte). The aluminum anodes were formed at 108 volts D.C. (the electrodes being separated a distance of about 2.5 cm. both during formation and the subsequent runs) until the leakage current reached a constant small value. Care was taken that the anodes should be completely formed before going further.

In order that the usual corrosion of the anode at the surface of the electrolyte should not take place the method was adopted of painting the anode with hot paraffin from a small groove machined on the anode (so that the surface exposed would be known) up a distance of about 2 cm. The electrode when placed in the cell was submerged about 0.5 cm. below the groove. After formation the anode was washed with distilled water, placed in naphtha for 20 minutes to dissolve off the paraffin, washed with water and then with alcohol, dried for 30 minutes at a temperature between 55° and 60°C., cooled and weighed.

A test was made to determine whether the paraffin coating could be satisfactorily removed by weighing a clean, unformed electrode, coating it with paraffin, removing the coating as described above, drying, and weighing again. It was found that correspondence of weighings within 0.2 mg. was readily obtainable. It was also deemed necessary to determine whether at the temperature employed (55°-60°C.) for drying there was any gradual change in weight of the electrode due to dehydration of the aluminum oxide film. That no error was introduced by the drying procedure is shown by Table 1.

Table 2 summarizes the experimental results obtained. The electrodes were made from aluminum rod of commercial purity. (It has been shown that the presence of small amounts of impurities does not appreciably affect the performance or characteristics of the aluminum-lead cell.) The electrodes were coated again with paraffin before making a run and the paraffin removed afterwards as described above.

In order to measure the leakage current a standard 0-10 milliammeter was connected in series with the cell. In Table 2, "X"

TABLE 1

TOTAL HOURS IN OVEN (AVERAGE TEMPERATURE 58°C.)	WEIGHT OF FORMED ELECTRODE
	grams
0.5	22.5265
1.5	22.5263
4.5	22.5264
16.5	22.5264

TABLE 2

ELEC- TRODE	LENGTH	DIAM- ETER	LEAK- AGE CUR- RENT	CURRENT DENSITY	VOLT- AGE APPLIED	TIME OF RUN	WEIGHT BEFORE RUN	WEIGHT AFTER RUN	CHANGE IN WEIGHT	"X"
	cm.	cm.	mla.	$\frac{\text{mla.} \times 10^{-3}}{\text{cm.}^2}$		hrs.	grams	grams	grams	
#1	5.8	0.97	1.3	73.5	108	20	22.5264	22.5240	-0.0024	0.0087
#2	5.8	0.93	0.8	47.0	108	76	21.7400	21.7402	0.0002	0.0204
	5.8	0.93	0.8	47.0	108	53	21.7402	21.7401	-0.0001	0.0142
#3	5.3	0.56	0.5	46.5	108	23	8.2010	8.2006	-0.0004	0.0039

is the theoretical loss in mass of the aluminum anode calculated from the flow of current on the assumption that Al^{+++} ions go into solution in accordance with Faraday's Laws of Electrolysis.

As is quite evident upon comparing the values in the columns headed "change of weight" and "X," no experimental agreement with the theory of solution of aluminum is to be had from the data. Although the calculated changes in weight "X" are small yet they would have been easily detected and measured by the apparatus used. An attempt was made by using higher voltages

at higher dilutions of the electrolyte to obtain larger leakage currents (of the order of 100 milliamperes at 500 volts) in the hope of obtaining larger values for "X" without proportionate increases in the possible errors. However, larger leakage currents cause greater evolution of heat, which in turn melts the necessary corrosion-preventing layer of paraffin.

Although the low melting-point of paraffin and its suspected inability to seal perfectly were pronounced disadvantages yet no other material possessing such desirable chemical inertness, ease of application, and solubility in some other solvent than water suggested itself.

Possible sources of error in the measurements are:

- (1) The polished electrodes seemed to have become slightly corroded beneath the protecting layer of paraffin, with the possible exception of No. 3. Such corrosion indicates a chemical action other than simple electrolytic solution.

- (2) There may have been failure to remove the last traces of paraffin, especially in cases where there was evidence of corrosion.

- (3) Minor errors may have been introduced by evaporation of the electrolyte, which occurred to a small extent. It was not considered advisable to cover the electrolyte with a layer of oil, due to fear of permanently contaminating the electrode when withdrawing it from the electrolyte.

In conclusion it may be said that the amount of experimental data presented is too limited in amount to prove or disprove any theory which would seek to account for leakage currents. However, the results obtained are, to the author's knowledge, the only quantitative observations which have been recorded on this particular phase of the general problem of the behavior of the aluminum-lead cell; and until definitely disproved they seem to indicate that there is no strict agreement between Faraday's Laws and the leakage current in so far as loss of mass of the anode is concerned. It must be remembered, however, that no account has been taken of related phenomena such as evolution of gas. In this connection it may be said that evolution of gas has been shown to be out of accord with Faraday's Laws.

The author is greatly indebted to Dr. L. E. Smith for his gen-

erosity in furnishing adequate facilities for carrying out this study and in giving liberally of his own time and advice.

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BALANCING CHEMICAL EQUATIONS

THE CONTRIBUTION OF OTIS COE JOHNSON (1880)

W. C. EBAUGH

Received June 30, 1932; published April 7, 1933

How to write the simplest chemical equations properly is a difficult problem for students beginning First Year Chemistry, and how to balance those that deal with oxidation and reduction is often a troublesome matter for even more advanced chemists. It is not uncommon to find college juniors and seniors unable to cope with equations of this type in spite of the three or four years experience they have had with them. Why is this so? How can explanations be made so as to minimize difficulties?

Perhaps the first method taught is that of "balancing by inspection"—a kind of fitting together of jig saw puzzles so as to have nothing left over. In spite of its apparent simplicity, however, there is always the possibility that the student may end with a result like the following:



In a freshman laboratory note book a student once wrote this equation, and when it was returned with the necessary corrections the student asked *why* the equation as he had written it was not correct. Did it not balance? And the unsatisfactory answer from the instructor was that "the books do not give it that way!"

With many students the second method learned is that depending upon "breaking the compounds up into their oxides"—a scheme that harks back to the days when Berzelius's dualistic theory was in its prime. This splitting up into basic and acidic oxides demands great knowledge concerning the constitution of the compounds involved or it may lead to results like these: (a) Should HgNO_3 be represented as HgO and NO_2 , or as Hg_2O and

N_2O_5 ? (b) Is BaSO_4 to be considered as BaO and SO_3 , or as BaO_2 and SO_2 ? The student finds all these formulas in his textbook or reference tables. How shall a choice be made? And what round-about, far-fetched subterfuges are resorted to in order to resolve many compounds into such factors! Consider the halides, ferro- and ferri-cyanides, hydrogen derivatives of nitrogen, carbon, silicon and other elements. The confusion in a student's mind when confronted with oxidations and reductions in compounds like these—containing *no* oxygen—is more profound than the teacher imagines.

Perhaps the greatest advance in handling equations involving oxidation and reduction was due to Otis Coe Johnson.¹ On July 7, 1880, he sent a communication to *The Chemical News* (London), and on July 30, 1880, it appeared under the title "Negative Bonds, and Rule for Balancing Equations." This article, occupying only one page, is shown in the accompanying illustration (Plate I).

In some of the formulas used apparently typographical errors appear. These can be detected easily; evidently the use of the new system of representing "bonds" caused some confusion. It is probable that the author never had an opportunity to correct proof inasmuch as only 23 days elapsed between the date of his paper at Ann Arbor, Michigan, and the publication of *The Chemical News* in London.

The Johnson method for balancing equations involving oxidation and reduction was presented in elaborated forms in successive editions of Prescott and Johnson's widely used textbook on Qualitative Analysis, but seems to have been granted grudging entrance into other works. In 1911-12 the present author showed it repeatedly to students in Europe—especially in Germany—and they marveled at its simplicity, but declared it was only a "trick"

¹ Johnson, Prof. Otis Coe. Chemistry. Born, Kishwaukee, Ill., Sept. 11, 1839. A.B., Oberlin, 68, A.M., 77; PhC., Michigan, 71. Instr. chem., Michigan 71-80, asst. prof. applied Chem., 80-88, *prof. qual. anal.* 89-1912. F.A.A., Chem. Soc., Mich. Pharmaceutical Assn., London Chem. Soc., Chem. Gesell. Originated the complete system of negative valence. (*American Men of Science*, J. McKeen Cattell. Second Edition, Science Press, New York (1910).)

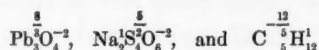
Died, Ann Arbor, Michigan, June 6, 1912 (*Proceedings*, Amer. Chem. Soc. (1913)).

and not founded upon accepted chemical theories. This attitude of mind seems to have been more or less common in America also.

And yet was not Johnson's idea of valence or "bonds" really the vision of a prophet? A whole generation had to pass before the electronic theory of valence came into its own, but when it finally arrived it accounted beautifully for the empirical rules given by Johnson. Change his term *bonds* into positive and negative valence, or into electrons subtracted and electrons added, or simply into the abbreviations + and -, and see how his original rules fit into modern nomenclature!

It will be objected that in peroxides the oxygen does *not* have a valence of "negative two." Johnson soon perceived this, and altered his statement to read "Oxygen has a valence of minus two, *except in peroxides*." In this class of compounds it was said to have a valence of negative (minus) *one*, an assertion borne out by later views of polar and non-polar valence, if merely the average or available valence of the oxygen atom be considered.

Similar objections might be urged against the fractional valences employed when dealing with substances like



but are such average valences more difficult to handle than are other means for completing equations involving reagents of such complex formulas?

It may be said, therefore, that Johnson's method for balancing equations dealing with oxidation and reduction reactions gives a good basis for such work, conforms to the modern idea of valence electrons and their function, and affords a glimpse at a possible atomic structure related definitely to valence and oxidation-reduction relations. Perhaps it bears about the same relationship to the present theory of atomic structure and valence that Newland's "Law of Octaves" did to the Periodic System.

CHEMICAL NEWS,
July 30, 1880.

Negative Bonds, and Rule for Balancing Equations.

51

THE CHEMICAL NEWS.

Vol. XLII. No. 1079.

NEGATIVE BONDS, AND RULE FOR BALANCING EQUATIONS.

By OTIS COE JOHNSON.

PROF. HUGO SCHWANERT, in his new "Lehrbuch der Pharmaceutischen Chemie," gives a rule for the construction of chemical equations. His method depends upon algebraical principles, as does also that of James Bottomley, read before the Manchester Philosophical Society, February 19, 1877, and given in the CHEMICAL NEWS, vol. xxxvii., p. 110.

My method is a chemical one, and is derived directly from principles of oxidation. It is founded upon a system of negative bonds. I here use the term bond in a sense partially new, which can better be understood by the illustrations that follow than by any definition which can be framed.

By the bonds of an element is meant the amount of oxidation it has sustained, or a bond is the measuring unit of oxidation.* The terms positive and negative are used not in an electrical but in a strictly numerical sense. The bonds of an element may always be ascertained with certainty by one of the following rules:—

(1.) Free elements have no bonds, and may be represented by zero, written thus— Cl^0 or Cl_2^0 , Ba^0 , Al^0 , &c.

(2.) Hydrogen in combination has always one bond, and it is positive, written thus, H^1 .

(3.) Oxygen in combination has two bonds, always minus, written thus, O^{-11} .

(4.) The bonds of the metals in combination are usually plus. The most prominent exceptions are their combinations with hydrogen, $\text{Sb}^{-111}\text{H}^{+111}$, $\text{As}^{-111}\text{H}^{+111}$.

(5.) The sum of the bonds of any compound is always zero. Thus, $\text{H}^1\text{N}^{+5}\text{O}_3^{-6}=0$; that is, the H has one positive bond, the N five positive bonds, and each atom of O has two negative bonds, and the three atoms have six negative bonds: six positive bonds added to six negative equals zero. In the same way, $\text{H}^1\text{Cl}^{+1}\text{O}^{-2}=0$, $\text{H}_2^{+2}\text{S}^{+6}\text{O}_4^{-8}=0$, $\text{H}_3^{+3}\text{P}^{+5}\text{O}_4^{-8}=0$, $\text{Ba}^{+2}\text{O}_2^{-4}\text{H}_2^{+2}=0$, $\text{Fe}^{+2}\text{O}_5^{-10}\text{H}_6^{+6}=0$, $\text{Ba}^{+2}\text{H}_4^{+4}\text{P}_2^{+6}\text{O}_8^{-8}=0$, or $\text{Pb}^{+2}\text{VI}(\text{PO}_4)^{-6}=0$.

(6.) Acid radicals are always negative, $\text{H}^1\text{I}^{+1}\text{O}_3^{-3}=0$, or $\text{H}^1(\text{IO}_3)^{-1}=0$, $\text{Pb}_3^{+6}\text{P}_2^{+6}\text{O}_8^{-8}=0$, or $\text{Pb}^{+2}\text{VI}(\text{PO}_4)^{-6}=0$.

The bonds of the radicals being equal to the number of atoms of hydrogen with which it is capable of combining.

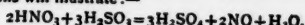
An oxidising agent is one that can increase the number of bonds of some other substance; hence oxidation of one substance must involve the reduction of some other. The number of bonds gained by one are lost by the other. The real bonds are transferred from the oxidising to the reducing agent. Thus in the equation—

$2\text{PbCrO}_4 + 5\text{Zn} + 16\text{HCl} = 2\text{Pb} + \text{Cr}_2\text{Cl}_6 + 5\text{ZnCl}_2 + 8\text{H}_2\text{O}$, it can be proven that the ten bonds lost by the lead chromate are transferred to the zinc.

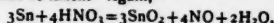
From these principles is derived a rule for writing equations, by which every equation involving oxidation may be balanced almost at a glance, if we know the products formed. The rule is:—The number of bonds changed in

* As this definition of bond is a new and provisional one, possibly the adoption of a new term might be less objectionable than the use of new definitions for the established term, bond, as a character in valence.

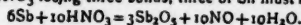
one molecule of each shows how many molecules* of the other must be taken, the words each and other referring respectively to oxidising and reducing agents. A few equations will illustrate:—



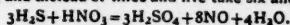
The nitrogen in HNO_3 has five bonds, and in NO it has two, losing three, therefore three molecules of H_2SO_3 must be taken. The sulphur in H_2SO_3 has four bonds, and in H_2SO_4 it has six, gaining two, therefore two molecules of HNO_3 must be taken. Again,—



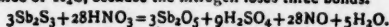
The Sn gains four bonds (free elements having no bonds), hence four molecules of HNO_3 must be taken, and the N of HNO_3 losing three bonds, three of Sn must be taken.



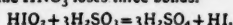
Here the rule calls for three of Sb and five of HNO_3 , but since the product Sb_2O_3 cannot be written with an odd number of atoms of antimony, we must double the amount of each, and instead of three and five take six and ten.



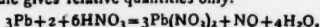
Here the sulphur in H_2S has -2 (minus two) bonds, and in H_2SO_4 it has $+6$, so it has gained eight bonds; hence we must take eight molecules of HNO_3 , and we take three of H_2S , because the nitrogen loses three bonds.



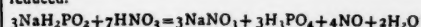
In this equation both the sulphur and the antimony of Sb_2S_3 are oxidised; each atom of sulphur gains eight bonds (as explained above), and the three atoms will gain twenty-four bonds. Each atom of the antimony gains two bonds, the two atoms gaining four bonds. These added to the twenty-four bonds gained by the sulphur, make twenty-eight (that is, one molecule of Sb_2S_3 gains twenty-eight bonds); hence we must take twenty-eight molecules of HNO_3 , also three of Sb_2S_3 , because the nitrogen of the HNO_3 loses three bonds.



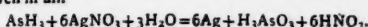
In this the rule calls for two HI and six of H_2SO_3 , but we take one and three, which are in the same proportion. The rule gives relative quantities only.



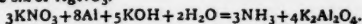
Here the rule requires two of HNO_3 , and shows that exactly two are reduced to NO ; but in order to make a solution of lead nitrate six more must be added, which are not reduced.



Here the phosphorus gains four bonds, and four of HNO_3 are reduced to NO ; but three more are required to liberate the hypo-phosphorus acid from $3\text{NaH}_2\text{PO}_2$, hence we take seven in all.



The arsenic in AsH_3 has minus three (-3) bonds, and in H_3AsO_3 it has plus three ($+3$); the gain is six, therefore take six of AgNO_3 .

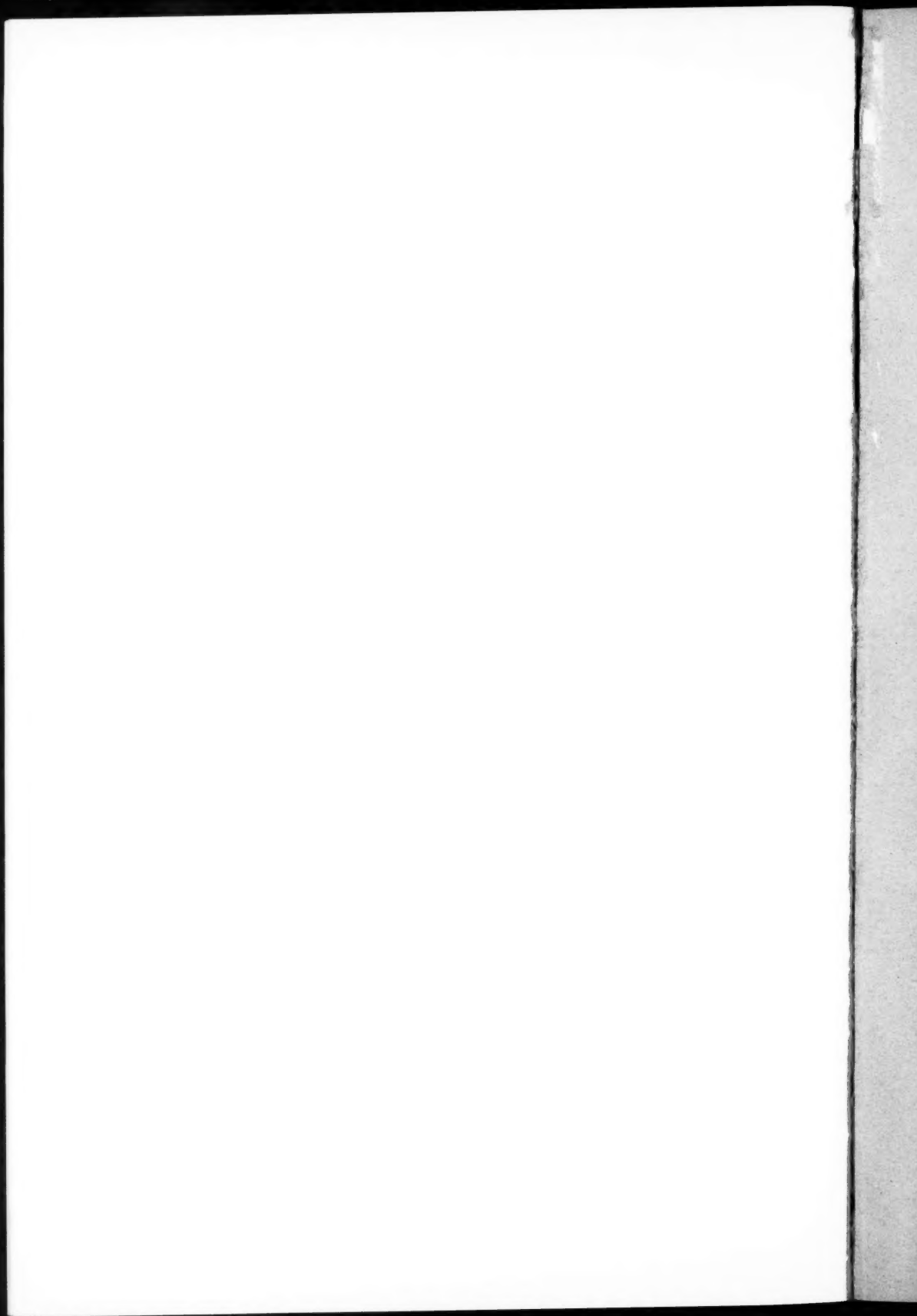


The nitrogen in NH_3 has -3 bonds, having lost eight, therefore take eight of Al; and as the Al gains three, take three molecules of KNO_3 .

This article will be followed by another showing the use of the rule in organic chemistry.

University of Michigan,
July 7, 1880.

* In case of free elements, to avoid complexity, atoms are represented as molecules.



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